U.S. Customs and Border Protection

AEROSTAT
Force Development Event (FDE) Evaluation
FINAL REPORT

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U.S. Customs and Border Protection

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Revision	Date	Reference (Table, Figure, or Paragraph Sections)	Brief Description of Change
A	July 21, 2014		Initial Release
B	July 22, 2014	Figures 26, 27	Graphic Corrections

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EXECUTIVE SUMMARY

Purpose. This Aerostat Force Development Event (FDE) Evaluation Final Report provides Office of Border Patrol (OBP) decision-makers the results, analysis, conclusions, and recommendations to support a decision for continued U. S. Border Patrol (USBP) Aerostat systems employment along the U.S./Mexico Border.

Background. In accordance with direction from the Secretary, Department of Homeland Security (DHS), Customs and Border Protection (CBP) Office of Technology Innovation and Acquisition (OTIA) has been tasked with exploiting Department of Defense (DoD) technologies identified in the Southwest Asia retrograde operations for immediate CBP reuse. In accordance with this direction, DoD Aerostats were deployed to the Rio Grande Valley (RGV) Sector in August 2012 and again in November 2013 for the FDE.

Scope. The six-month Aerostat FDE was conducted from November 1, 2013 to April 30, 2014. Two Rapid Aerostat Initial Development (RAID) systems and one Persistent Ground Surveillance System (PGSS) were deployed to RGV Sector for this FDE. The Aerostat FDE Evaluation included an RGV onsite evaluation providing a limited assessment of operational suitability/effectiveness of the Aerostat systems and a determination of operational utility of the (b) (7)(E)) technology insertion (FDE Objectives 1 and 2). A Return on Investment (ROI) analysis (FDE Objective 3) to determine mission outcome benefit was conducted by OTIA concurrently with the Aerostat FDE operations.

Results.

Onsite Evaluation

Operational Effectiveness. Using historical data from November 2012 – April 2013 (FY13) as a comparative baseline to the FDE data collected from November 2013 to April 2014 (FY14), there was a (b) (7)(E) increase in the total number of apprehensions from the FY13 time period to the FY14 time period in the three station areas of responsibility (AOR) within RGV sector where Aerostats were deployed. Furthermore, Aerostat assisted apprehensions accounted for (b) (7)(E) of all apprehensions in the three station AORs during the FDE. However, from the data collected, a definitive conclusion that these Aerostat assisted apprehensions would or would not have occurred without the presence of the Aerostat system cannot be made.

Environmental and Safety. (b) (7)(E)

Reliability, Availability, and Maintainability. The operational availability for the PGSS, RAID 1, and RAID 2 systems were (b) (7)(E) (b) (7)(E) (b) (7)(E)

(b) (7)(E) The availability for the PGSS, RAID 1, and RAID 2 aerostat balloon operations were (b) (7)(E) System meantime to repair varied between (b) (7)(E) (b) (7)(E) on the RAID systems. Mean time between failures ranged from approximately (b) (7)(E) (b) (7)(E) on the RAID systems. These two metrics were not collected for PGSS. The majority of failures that occurred during the FDE were attributed to (b) (7)(E) (b) (7)(E) for both the RAID and PGSS.

(b) (7)(E) Technology Insertion

(b) (7)(E) .

ROI Analysis

Annual budgeted Operations and Maintenance costs average $5.65 million and $4.69 million assuming contracting labor for the RAID and PGSS, respectively. Manpower is the primary cost driver for RAID and PGSS operations. The use of either USBP or National Guard O&M crews instead of contractor labor provides an average annual cost avoidance of 37% and 28% for the RAID and PGSS, respectively.

Value analysis of the weighted area of coverage (38%), cost (24%), and operational availability (b) (7)(E) factors showed that (b) (7)(E)

Conclusions and Recommendations.

Onsite Evaluation

With the scope of this onsite evaluation, the Aerostat systems contributed to mission accomplishment (operational effectiveness) while providing a transportable (not mobile) and relatively high (RAID (b) (7)(E) and PGSS (b) (7)(E) operational availability when neglecting the (b) (7)(E) on the aerostat balloon.

The potential value of Aerostat systems as a force multiplier should be further examined, the tactics, techniques and procedures (TTPs) for Aerostat operations and maintenance should be further developed, and component reliability addressed to maximize the utility of the Aerostat

systems. In addition, USBP TTPs should be developed to preclude unforeseen issues from happening.

(b) (7)(E) Technology Insertion

For this evaluation, the (b) (7)(E) provided enhanced effectiveness. (b) (7)(E)

Return on Investment Analysis

Within the scope of this analysis, Aerostat airborne components provide greater cumulative coverage than towers or other ground-based systems while both RAID and PGSS towers provide coverage that is similar to the coverage that is provided by legacy systems. While the RAID and PGSS aerostats provide the lowest cost per area of coverage, the lower Ao (b) (7)(E) (b) (7)(E)) suggests legacy systems might be a better choice. Overall, the PGSS provides the greatest value when compared to legacy systems as determined based on RGV RAID site performance.

Consideration should be given to:

- (b) (7)(E)
- the trade space between cost per area of coverage verses operational availability should be taken into account when making future deployment decisions; and,
- the use of either USBP or National Guard crews for O&M to provide significant cost avoidance over contractor labor operations.

END OF EXECUTIVE SUMMARY

1 INTRODUCTION

1.1 Purpose and Objectives

The purpose of this Aerostat Force Development Event (FDE) Evaluation Final Report is to provide the results, analysis, conclusions, and recommendations to support a decision for continued U. S. Border Patrol (USBP) Aerostat systems employment along the U.S./Mexico Border and provide information to assist Office of Border Patrol (OBP) in identifying a near and longer term plan for complementary border surveillance applications.

OBP requested the OTIA Operational Integration and Analysis Directorate (OIAD) Operational Evaluation Branch (OEB) conduct this FDE and concurrent evaluation. The top-level Aerostat FDE evaluation objectives, as documented in the U.S. Customs and Border Protection (CBP) Operational Interest Statement for Aerostat Systems (Appendix A, Reference 1), are provided in Table 1.

Table 1: Top-Level Evaluation Objectives

	Objective
Objective 1	Limited assessment of Aerostat Systems' Operational Effectiveness.
Objective 2	Limited assessment of Aerostat Systems' Operational Suitability.
Objective 3	Aerostat/Legacy systems mission outcome benefit (return on investment).

1.2 Background

In accordance with direction from the Secretary, Department of Homeland Security (DHS), CBP's Office of Technology Innovation and Acquisition (OTIA) has been tasked with exploiting Department of Defense (DoD) technologies identified in the Southwest Asia retrograde operations for immediate CBP reuse. In accordance with this direction, DoD Aerostats were deployed to the Rio Grande Valley (RGV) Sector in August 2012. OEB conducted an Aerostat Operational Utility Evaluation (OUE) in August 2012 and established Aerostat system potential utility for the USBP mission (Appendix A, Reference 2).

1.3 Scope

This report provides an evaluation of data from the six-month Aerostat FDE conducted from November 1, 2013 to April 30, 2014 in the Rio Grande Valley (RGV) Sector Area of Responsibility (AOR). Two Rapid Aerostat Initial Development (RAID) systems and one Persistent Ground Surveillance System (PGSS) were deployed to RGV Sector for this FDE.

The Aerostat FDE Evaluation included an RGV onsite evaluation (Objectives 1 and 2) of the Aerostat systems and a (b) (7)(E)) technology insertion Operational Utility Evaluation (OUE). A Return on Investment (ROI) analysis (Objective 3) was conducted by OTIA concurrently with the Aerostat FDE operations.

1.4 System Description

1.4.1 Rapid Aerostat Initial Development

The RAID (see Figure 1) provides 24-hour, 360-degree, high resolution, day and night surveillance capability for enhanced target recognition and situational awareness. The significant contribution that aerostats make is the extended line-of-sight (LOS) sensor range and the increased percentage of the terrain visible within that LOS as compared to ground-based only sensor platforms. The RAID, as configured for this FDE, includes four major segments: (b) (7)(E)

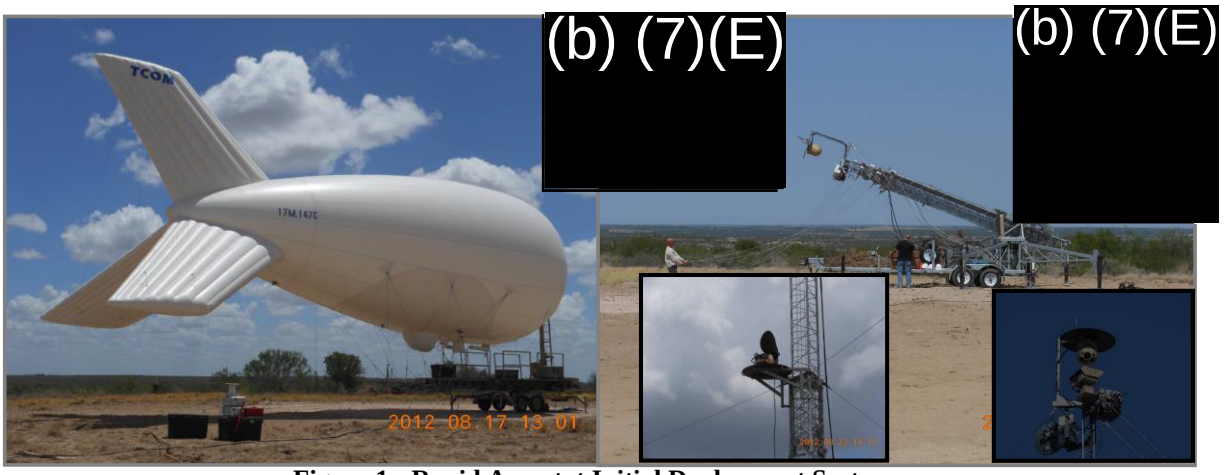


Figure 1: Rapid Aerostat Initial Deployment System

For both the Aerostat and tower, the multi-spectral sensor suite consisted of a (b) (7)(E) .

1.4.2 Persistent Ground Surveillance System

The PGSS (see Figure 2) is designed to provide 24-hour, 360-degree detection, surveillance, and monitoring. The significant contribution that aerostats make is the extended line-of-sight (LOS) sensor range and the increased percentage of the terrain visible within that LOS as compared to ground-based only sensor platforms. The PGSS, as configured for this FDE, is comprised of four major segments: (b) (7)(E) .

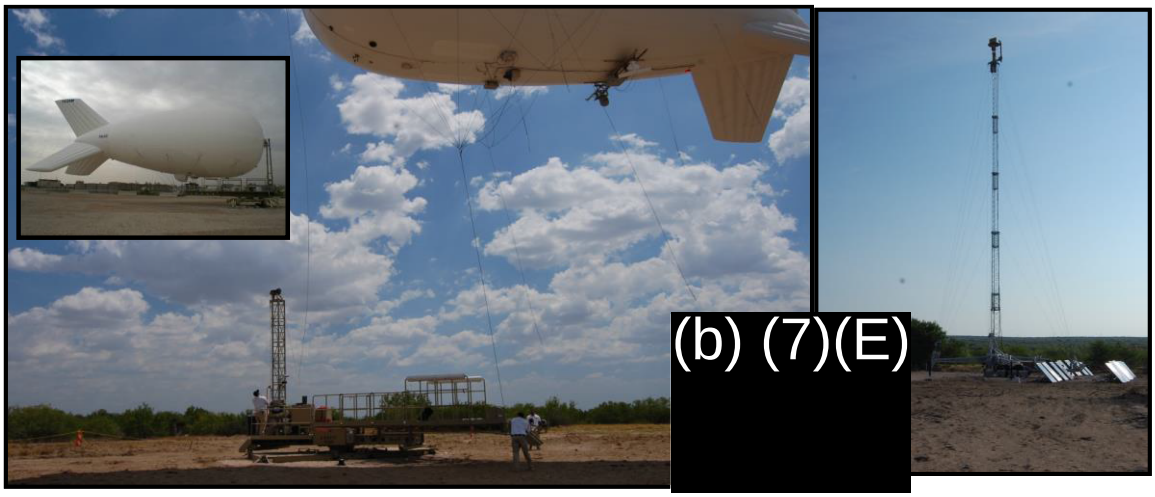


Figure 2: Persistent Ground Surveillance System

1.4.3 Systems Summary

A summary description of the systems and their operating limitations are provided in Table 2.

Table 2: Summary Systems Description

		PGSS	RAID
Aerostat	Size:	(b) (7)(E)	
	FDE Operating Limits:		
	Camera:		
	Radar:		
	Mooring:		
Tower	Height:		
	Camera:		
	Radar:		

1.5 RGV Concept of Employment

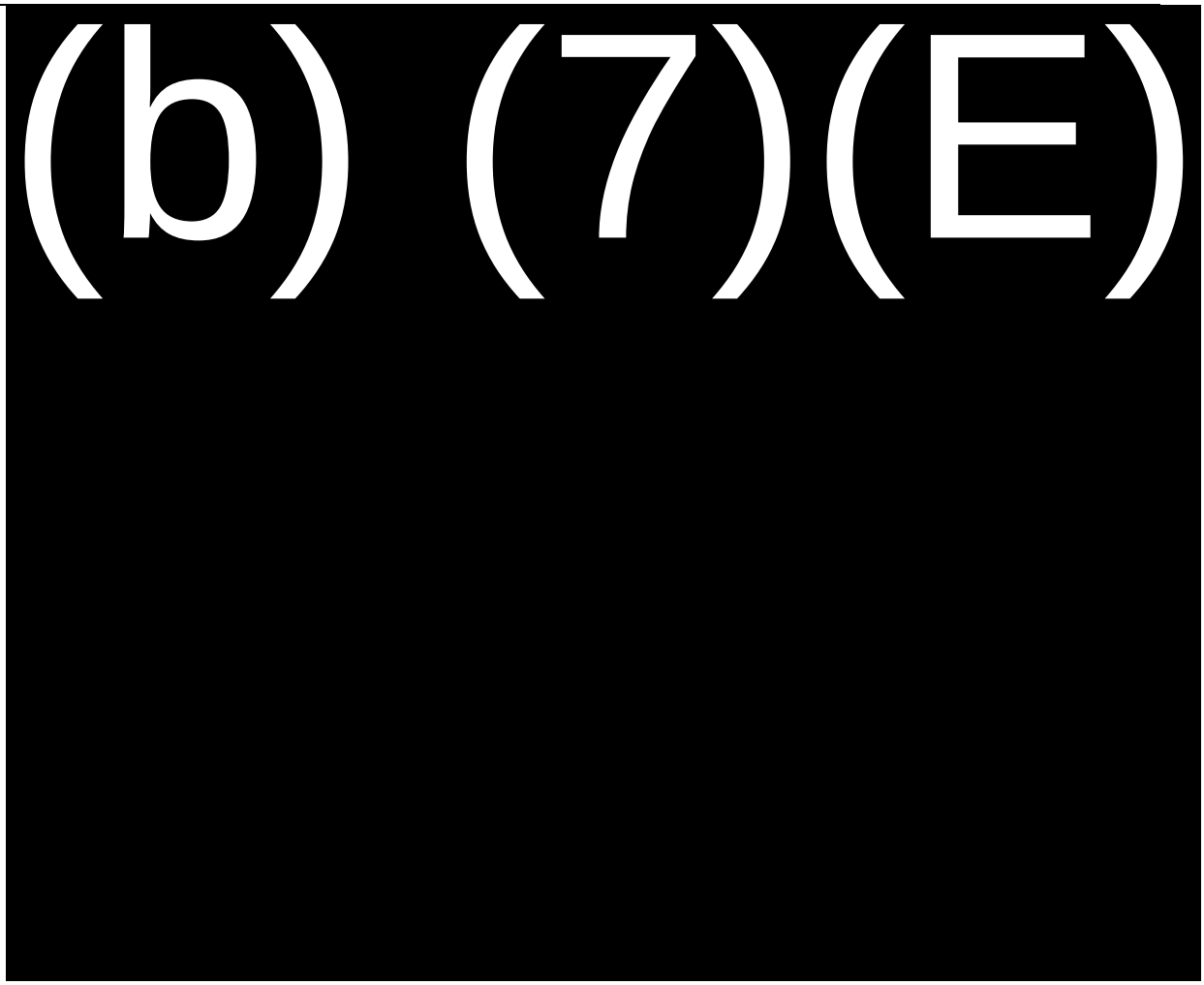
Three Aerostat systems were fielded at USBP selected pre-designated sites within the RGV Sector's (b) (7)(E) stations as depicted in Figure 3. The two RAID systems were deployed at (b) (7)(E) and the PGSS was fielded at (b) (7)(E). Duration of deployment and site location are as follows:

- Site 1 (RAID Operational **November 2, 2013 – April 30, 2014**): (b) (7)(E) [longitude - (b) (7)(E) degrees and latitude (b) (7)(E) degrees]
- Site 2: (RAID Operational **November 29, 2013 – April 30, 2014**): (b) (7)(E) [longitude - (b) (7)(E) degrees and latitude (b) (7)(E) degrees]
- Site 3: (PGSS Operational **January 14, 2014 – April 30, 2014**): (b) (7)(E) longitude (b) (7)(E) degrees and latitude (b) (7)(E) degrees]

For this FDE, the RAID and PGSS vendor crews were responsible for maintaining the system in an operationally ready state defined as up and operating aerostat and/or tower and the GCS. Border Patrol Agents (BPA), designated as Aerostat system operators ((b) (7)(E) per shift), received on-the-job (OJT) operator/sensor training by the onsite PGSS/RAID vendors. The systems were operated, 24-hours a day, 7-days a week during this six-month period with the following exceptions when the RAID systems were only operational 12-hours a day, 7-days a week due to limited crew availability:

- RAID 1 (Site 1 (b) (7)(E): December 5, 2013 through March 16, 2014
- RAID 2 (Site 2 : November 30 through December 23, 2014
- RAID 2 (Site 2 : February 4 through February 17, 2014

All FDE operations were in accordance with the U.S. DHS CBP Operations Order Report Aerostat Force Development Event (Appendix A, Reference 3.)



2 ONSITE EVALUATION

2.1 Methodology and Approach

Three operational issues (OIs) were identified for the onsite evaluation:

- OI-1: Does the Aerostat System provide adequate ground surveillance coverage to provide increased situational awareness in the operational environment?
- OI-2: Can the Aerostat system be deployed/redeployed in the (b) (7)(E) operational environment?
- OI-3: Can the Aerostat system be employed in the (b) (7)(E) operational environment?

The operational effectiveness (OE) assessment included data recorded from live operations detections resulting in Aerostat system assisted apprehensions. Scripted scenarios to determine operational effectiveness were limited to the (b) (7)(E) evaluation in accordance with the OBP Operations Decision Paper (Appendix A, Reference 4); therefore, OE analysis provided in Section 2.2 (Operational Effectiveness) is limited to reported live operations data. Deployability

was assessed by examining pre-deployment preparation time, transport, and system erect crew/time requirements. This analysis is addressed in Section 2.3 (Deployability). The operational suitability (OS) assessment included analysis of the data collected to determine reliability, availability, maintainability (RAM), and to document failures and safety issues experienced. This analysis is addressed in Section 2.4 (Operational Suitability).

All OE, deployability, and OS data collection were made by BPAs assigned per shift and recorded into the (b) (7)(E) data collection system database. Prior to data collection, each assigned BPA operator was trained on the data collection process including the data forms to be filled out per shift.

2.2 Operational Effectiveness – Live Operations (OI-1)

2.2.1 Detailed Methodology and Approach

OE was examined in two ways. The first considered the contribution of the Aerostat system to the overall mission accomplishment. The second compares Aerostat FDE apprehensions to historical data. Metrics were examined for each of the three AORs in which an assist was made by an Aerostat system during the detection/track as compared to when it was not. The percentages of Aerostat assisted USBP apprehensions were then computed for each AOR. Total Station/Zone apprehension data including historical data were obtained from Border Patrol (b) (7)(E) and Aerostat system data from the (b) (7)(E) database.

2.2.2 Limitations and Constraints

OE assessment was limited to data collected from live operations and the accuracy of the data entry into the (b) (7)(E) data collection system. Aerostat system detections and tracks leading to apprehensions are limited to EO/IR sensors data recorded. Operations for RAID 1 and RAID 2 were reduced to 12 hours per day during part of the time period as described in Section 1.5.

(b) (7)(E)

2.2.3 OE Findings and Analysis

Aerostat Contribution to Mission

The contribution each Aerostat system made to mission accomplishment as measured by apprehensions during the FDE time period between November 1, 2013 and April 30, 2014 is presented in Figure 4. This figure depicts the overall apprehensions by station during this time period and denotes the percentage of overall apprehensions that were attributed to Aerostat system detect/track (termed an aerostat assist).

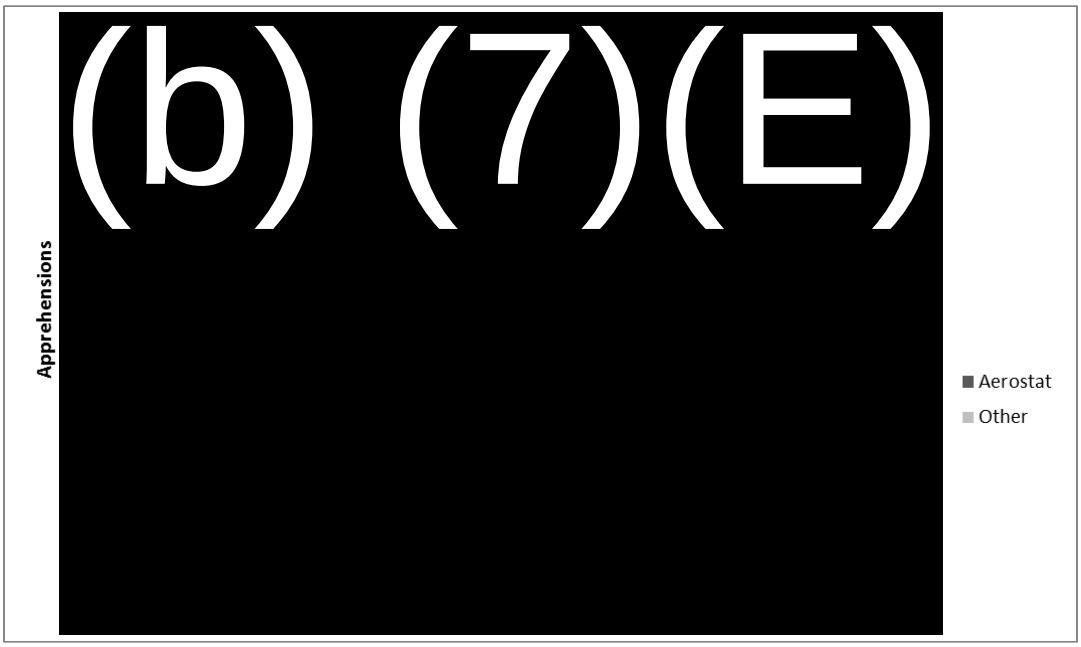


Figure 4: Apprehensions by Station AOR (Nov 2013 – Apr 2014)

Figure 5 shows the total overall apprehensions within the specific/adjacent zones of each station where the Aerostat system had coverage and was operating during the same time period. Zone maps identifying the three Aerostat sites are provided in Figures 6 and 7. As before, the percentage of apprehensions attributed to an Aerostat system assist is also denoted as a percentage. (b) (7)(E)

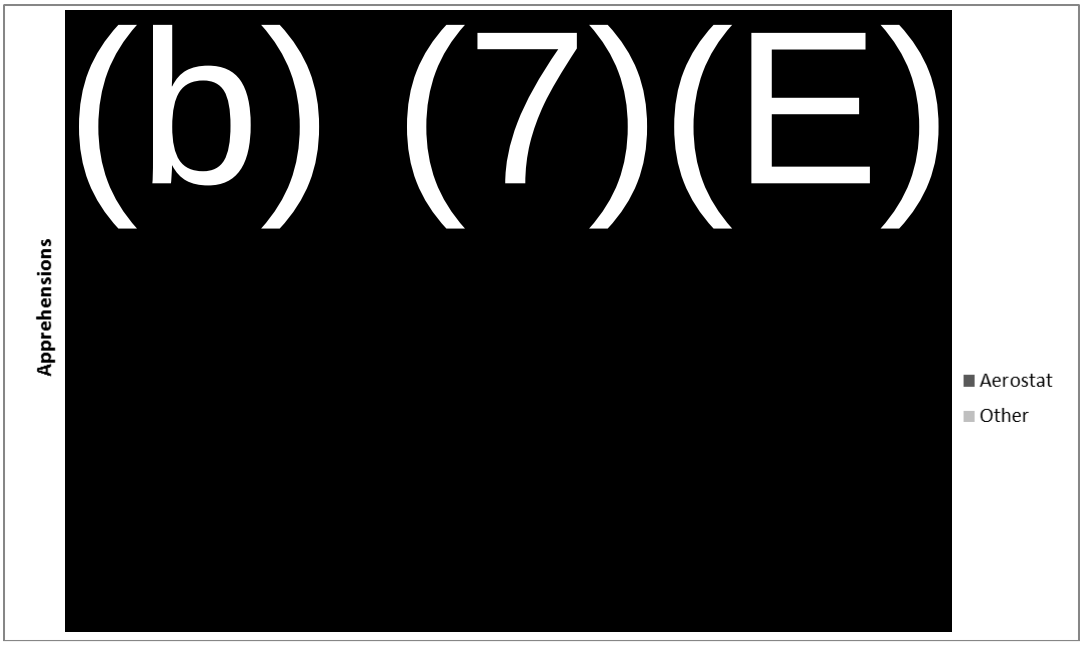
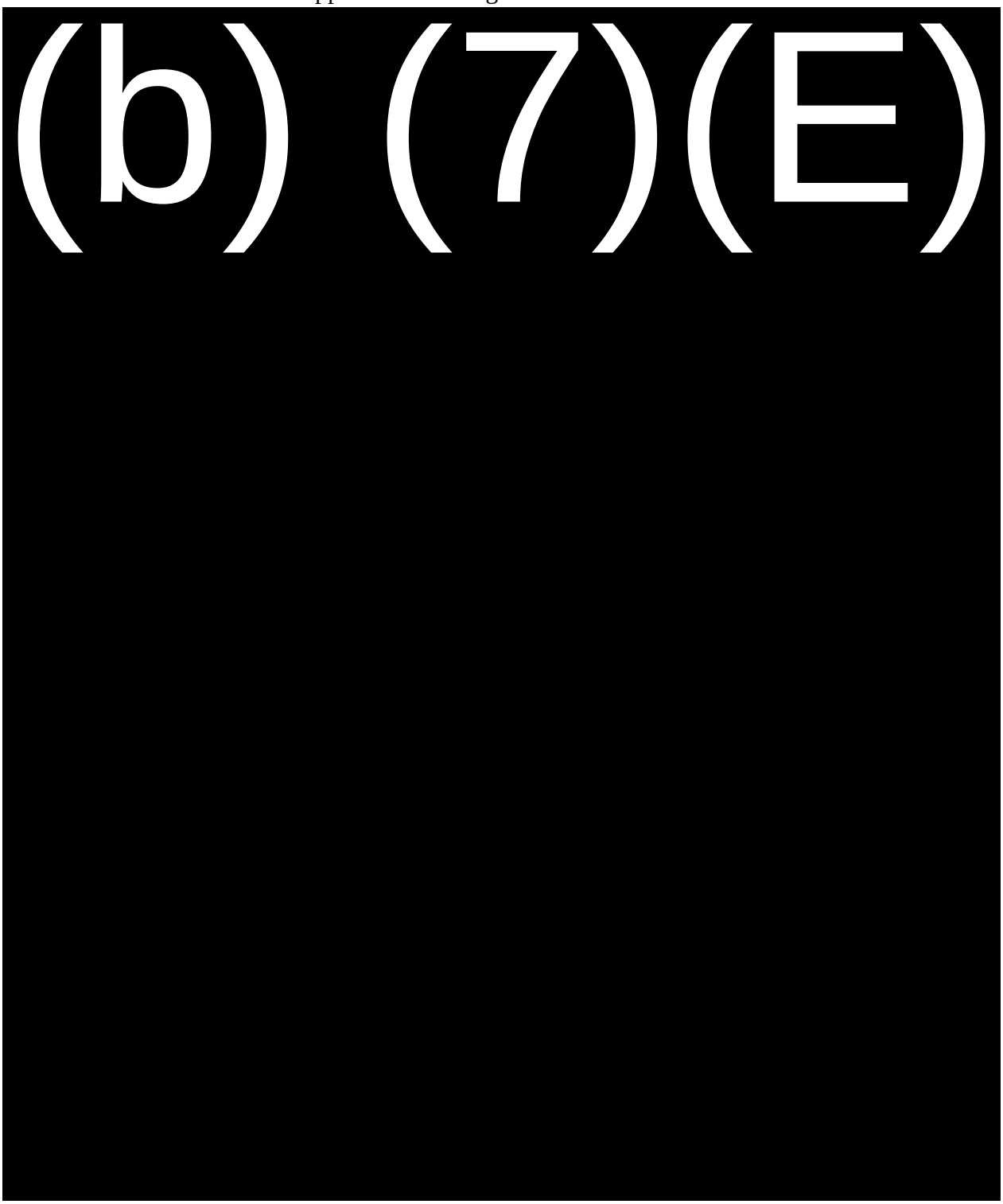
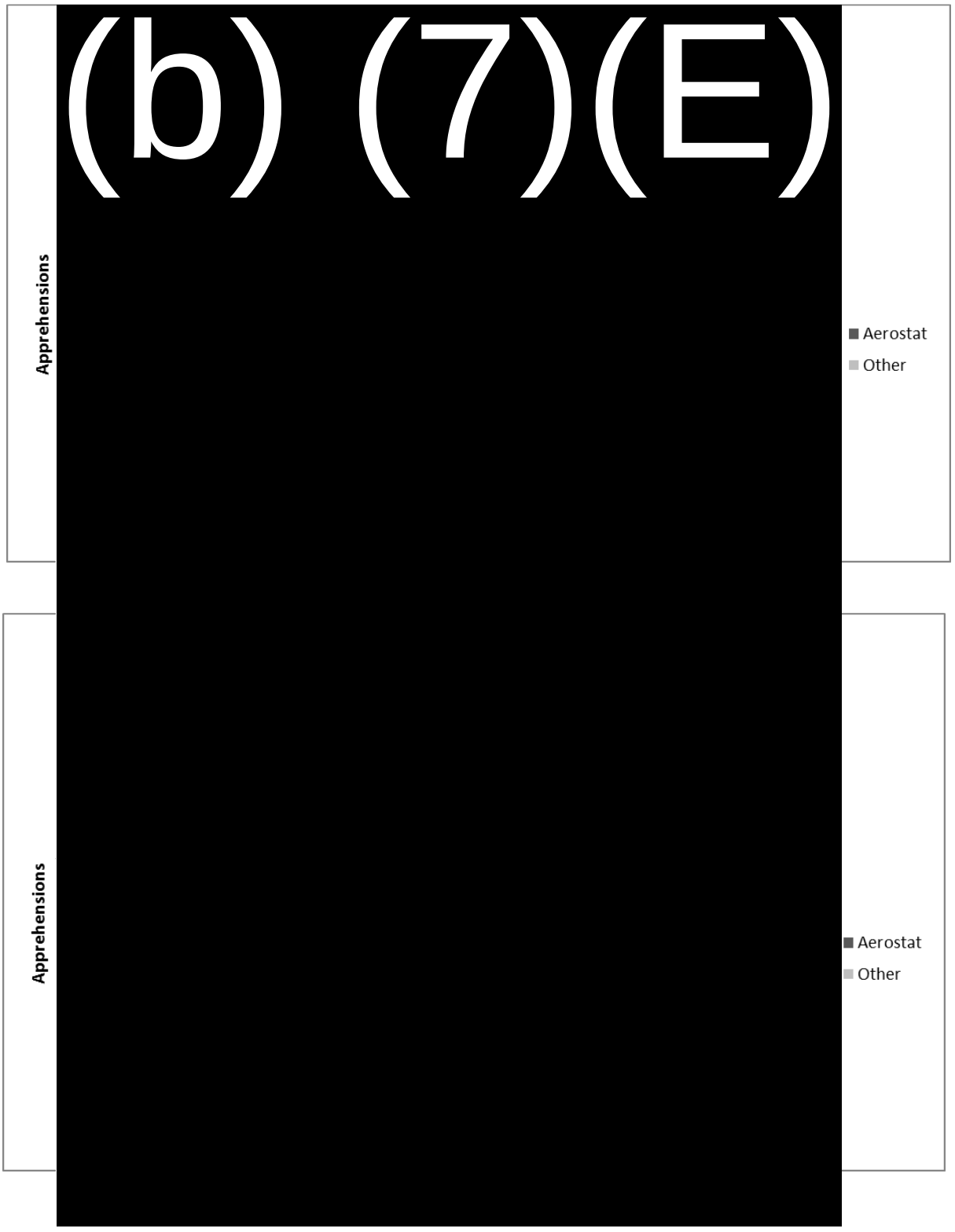


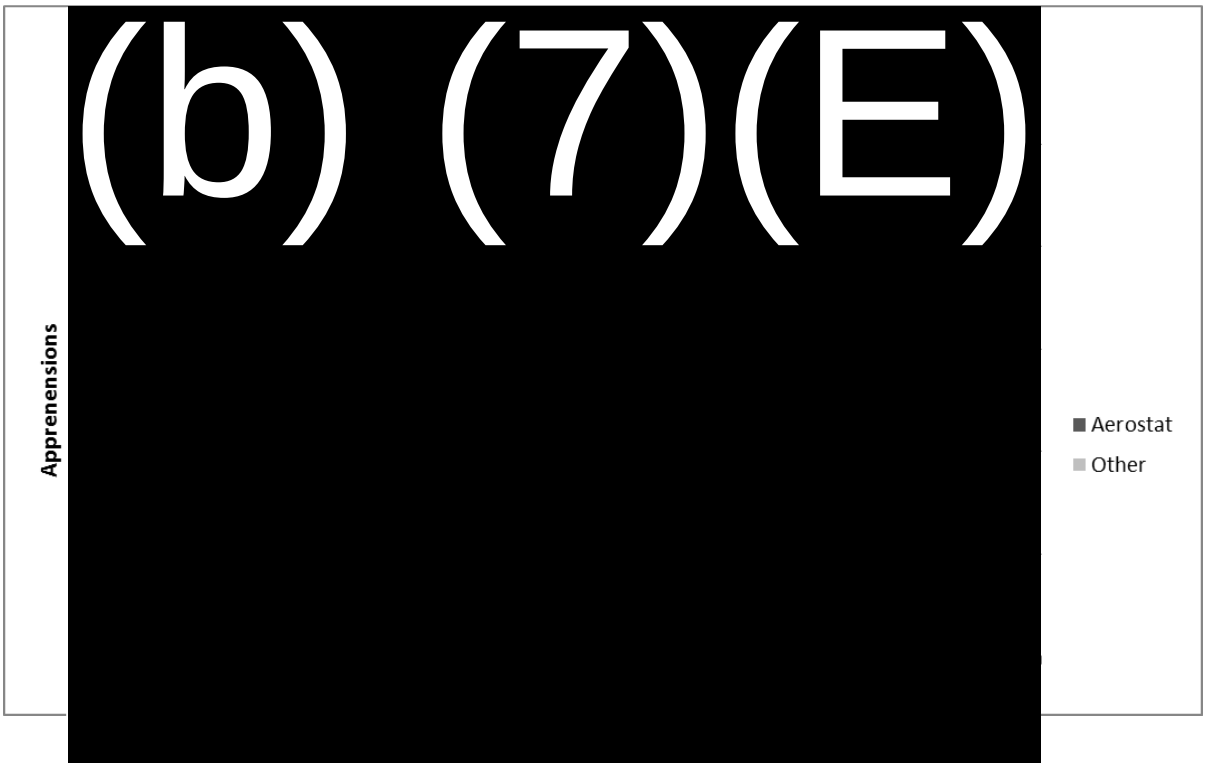
Figure 5: Apprehensions by Aerostat Site/Adjacent Zones

Focusing only on the specific/adjacent zones where the Aerostat systems were operational, it is intuitive that the proportion of aerostat assisted apprehensions goes up. The significant number of assisted apprehensions in (b) (7)(E) is attributed to the remote location of PGSS from the border were the time to track/apprehend IoIs is greater.



Figures 8-10 show the total overall apprehensions within the specific/adjacent zones for the time periods an Aerostat system was operational.





In addition to total apprehensions, Figure 11 shows the total gotaways reported at each Aerostat system site. Based on the reported data, gotaways represented (b) (7)(E) total apprehensions, for (b) (7)(E) and the other two sites respectively.

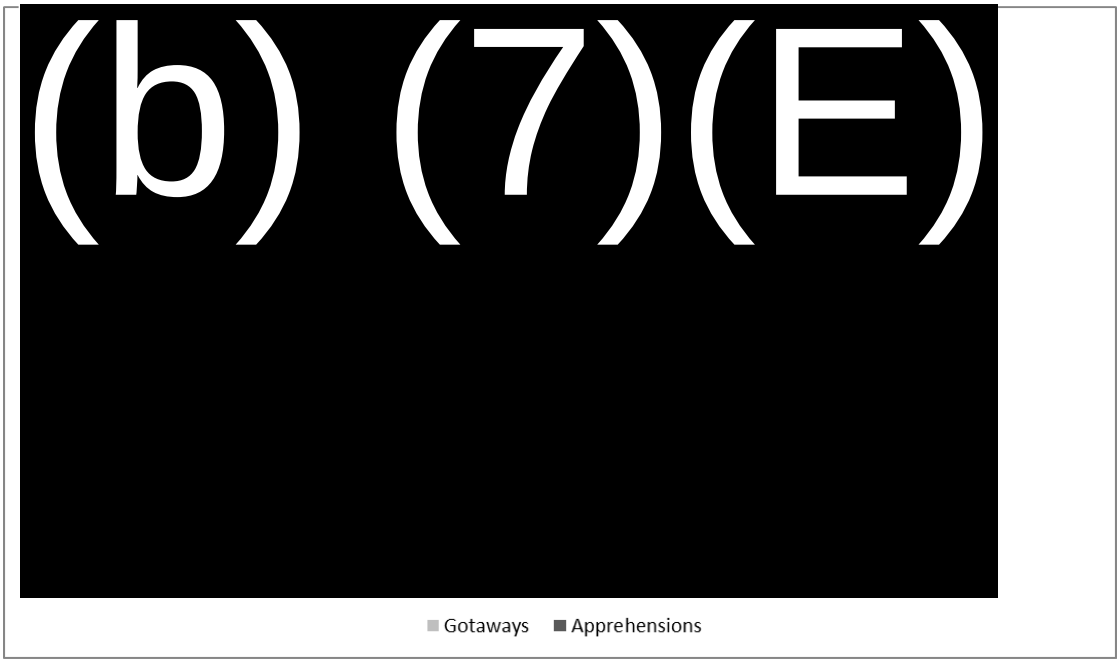


Figure 11: Total Apprehensions and Gotaways Observed During Onsite Evaluation

AOR Metric Comparison – FDE vs. Historical

The second part of this assessment made direct comparisons of the numbers of apprehensions that occurred during the FDE time period to historical data. For comparison purposes, similar data for the same time period of the previous year, November 1, 2012 through April 30, 2013 (FY13) was used. Because zone boundaries were redrawn during FY14, the comparison data used was at the station level, rather than at the zone level.

Overall within the three AORs, there was a (b) (7)(E) increase in the total number of apprehensions from the FY13 time period to the FY14 time period. Figure 12 shows the monthly apprehensions during FY13 and FY14 during the months of November thru April for each FY. For the FY14 data, the total percentage of each month's apprehensions that was aerostat assisted is depicted by the darker portion of the column. The corresponding percentage of that month's apprehensions that were aerostat assisted is also shown above the column.

The side by side comparison between FY13 and FY14 also shows the cyclic nature of apprehensions. In both years, apprehensions decreased during the months of December and January, then increase sharply during the spring. In examining the apprehension results side by side, there is a sharp increase in apprehensions is FY14 when compared to FY13, even when aerostat assisted apprehensions are excluded. From live operations data alone, there is no way to make a definitive conclusion that the aerostat assisted apprehensions would or would not have occurred without the presence of the Aerostat system. This would require further testing with scripted scenarios.

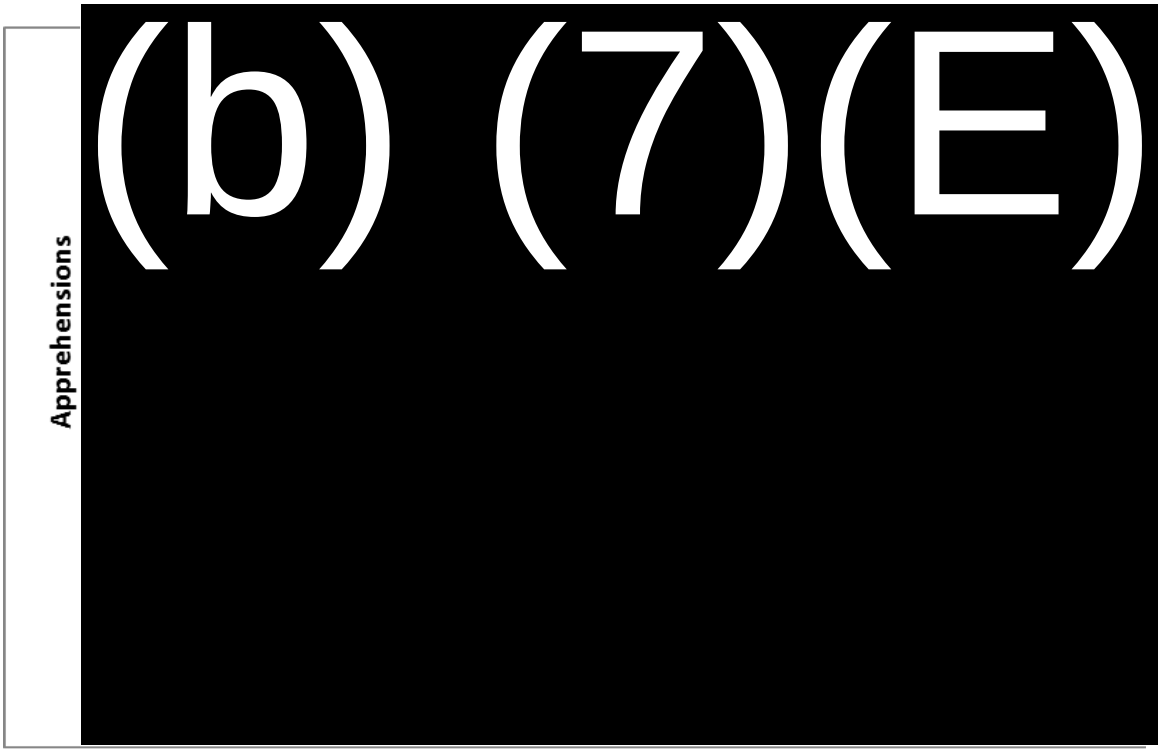


Figure 12: Total Apprehensions Historical Comparison

(b) (7)(E)

Aerostat operations in (b) (7)(E) took place January 14, 2014 through April 20, 2014. Overall within the (b) (7)(E) AOR, there was a (b) (7)(E) increase in total apprehensions from the FY13 time period to the FY14 time period. Figure 13 shows the monthly apprehensions during FY13 and FY14 during the months of November thru April for each FY. For the FY14 data, the total percentage of each month's apprehensions that was aerostat assisted is depicted by the darker portion of the column. The corresponding percentage of that month's apprehensions that were aerostat assisted is also shown above the column.

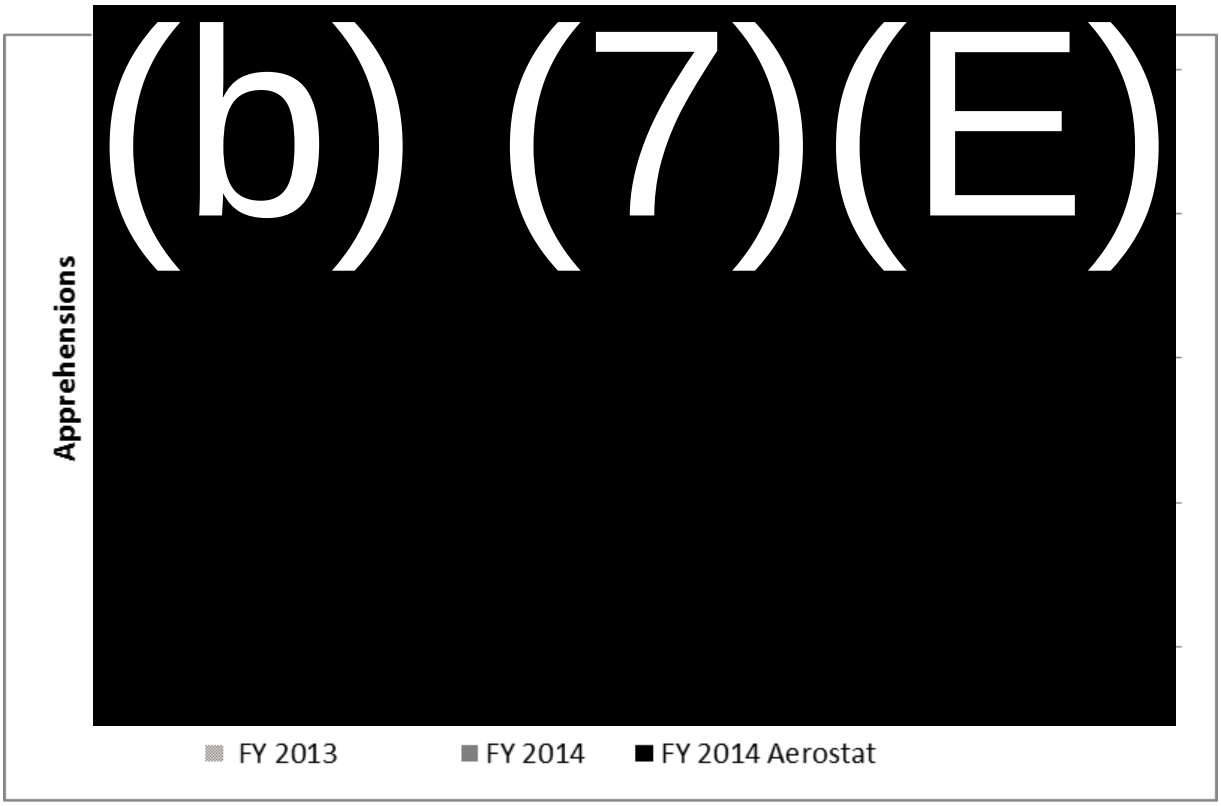


Figure 13: (b) (7)(E) Apprehensions Historical Comparison

(b) (7)(E)

Operations in (b) (7)(E) took place from November 29, 2013 – April 30, 2014. Overall within the (b) (7)(E) AOR, there was a (b) (7)(E) increase in apprehensions from the FY13 time period to the FY14 time period. Figure 14 shows the monthly apprehensions during FY13 and FY14 during the months of November thru April for each FY. For the FY14 data, the total percentage of each month's apprehensions that was aerostat assisted is depicted by the darker portion of the column. The corresponding percentage of that month's apprehensions that were aerostat assisted is also shown above the column.

While the percentages of (b) (7)(E) apprehensions with aerostat assist may be lower than the other participating AORs, it should be noted that the evaluation did not begin in (b) (7)(E) until November 29, 2013. The historical data presented during the analysis was organized by month, so the small percentage of assisted apprehensions in November is due in part to two operational days occurring in November.

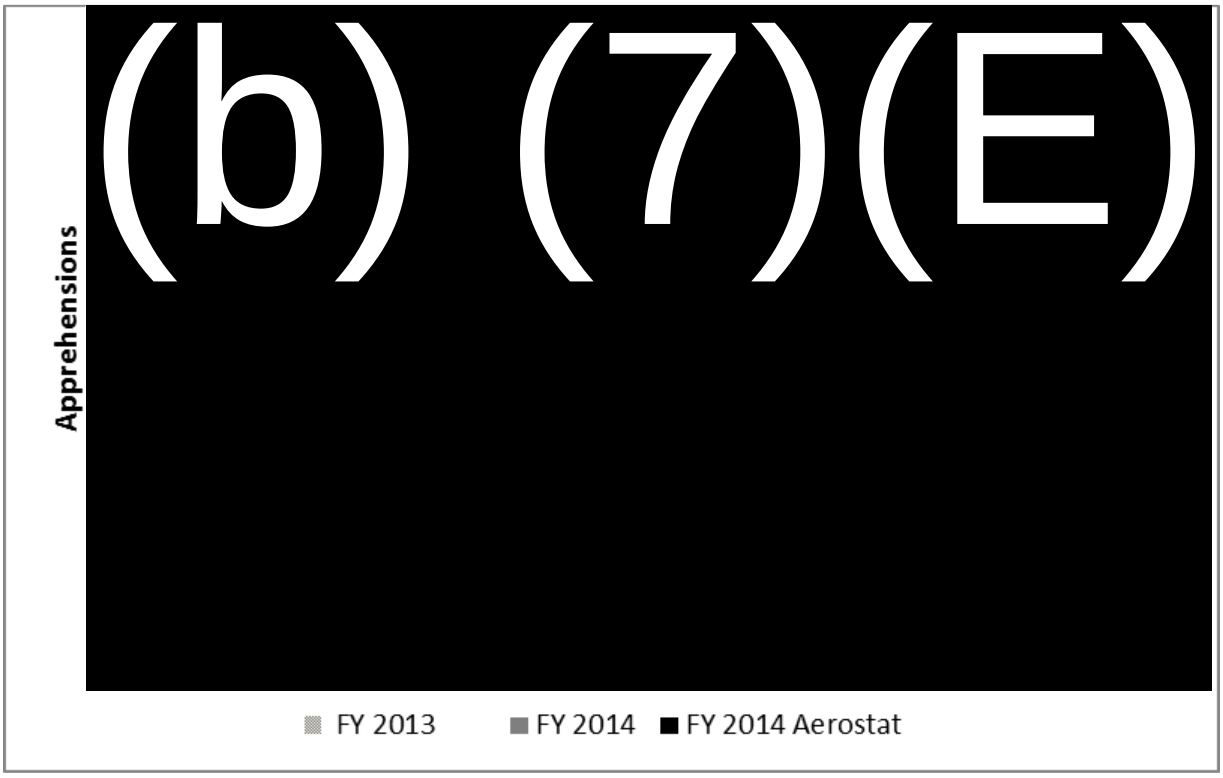


Figure 14: (b) (7)(E) Apprehensions Historical Comparison

(b) (7)(E)

Operations within (b) (7)(E) took place from November 2, 2013 through April 30, 2014. Overall within the (b) (7)(E) AOR, there was a (b) (7)(E) increase in apprehensions from the FY13 time period to the FY14 time period. Figure 15 shows the monthly apprehensions during FY13 and FY14 during the months of November thru April for each FY. For the FY14 data, the total percentage of each month's apprehensions that were aerostat assisted is depicted by the darker portion of the column. The corresponding percentage of that month's apprehensions that were aerostat assisted is also shown above the column.

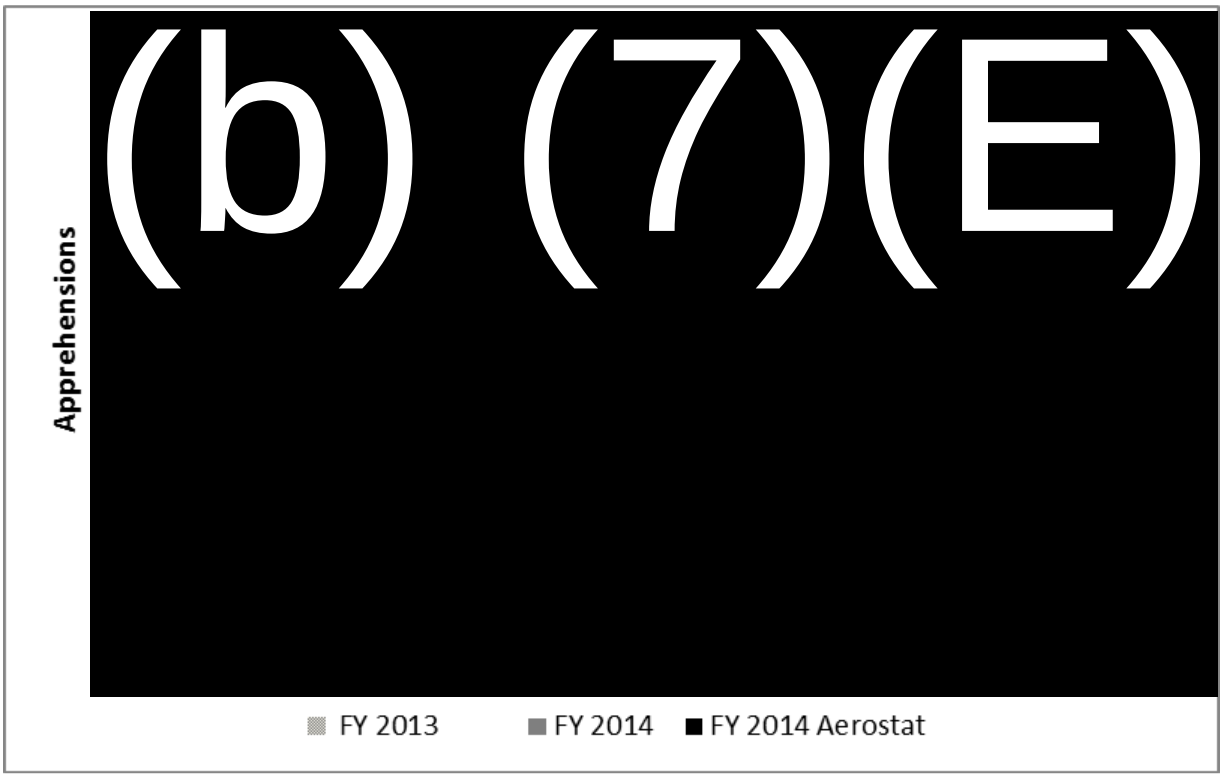


Figure 15: (b)(7)(E) Apprehensions Historical Comparison

2.3 Deployability (OI-2)

This OI is intended to support the assessment of the deployability of the Aerostat systems. It is composed of pre-deployment preparations including obtaining permissions, approvals, and certifications, as well as transportation and erect/stow requirements.

2.3.1 Limitations and Constraints

For this FDE, there was no attempt to limit personnel participation to only the contractor crew; therefore, the erect times and crew sizes may not be representative of what USBP will experience in future deployments. The systems remained operational at the end of the FDE; therefore, stow/transport preparation times/crew sizes were not measured. In addition, redeployments to alternate sites were not conducted.

2.3.2 Pre-Deployment Requirements

There are six major factors that must be satisfied for Aerostat system deployment prior to operations. These include: 1) site identification/selection, 2) land right of entry for use of private land, 3) site preparation, 4) environmental impact clearance, 5) FAA clearance for aerostat flight operations, and 6) frequency allocation clearance to activate the systems' radar. Site identification/selection was the responsibility of RGV Sector and the process/time required was not recorded by the evaluation team however site surveys were conducted by the

RAID/PGSS contractor teams to confirm the sites selected by USBP were acceptable for operations. These site surveys required a total of 22 days for all sites. Table 3 identifies the time required for factors two through six as a function of the site/equipment type. A common frequency allocation clearance request was made for both the RAID and PGSS which was granted in 60 days.

Table 3: FDE Pre-Deployment Requirements by Site

Factor (in days)	Site 1 (b) (7)(E)	Site 2 (b) (7)(E)	Site 3 (b) (7)(E)
Real Estate/Land Right of Entry	9	60	44
Site Preparation	4	1	1
Environment Impact Clearance	21	40	32
FAA Clearance	33	33	33
Frequency Allocation Clearance	60		
Elapsed Total Time – Start to Finish	80	119	160

2.3.3 Transport and Erect/Stow

Results of the data collected are presented in Table 4. Deployment of the Aerostat systems required four flatbed tractor trailers with access to all sites via highway and semi-improved roads. (b) (7)(E) . In the case of this FDE, all sites were prepared.

Table 4: System Deployability

Measure of Suitability	RAID (Site 1)		PGSS	
	Aerostat	Tower	Aerostat	Tower
Erect Time (including unload time)	63 hours 5 mins	9 hours 31 mins	11 hours 39 mins	7 hours 39 mins
Erect Crew Size	9	9	9	9
Transportation Resources	Four 34 ft flatbed trucks + one 24-27 ft helium transport			
Site Access Terrain Type	Improved/Semi-Improved Roads		Improved/Semi-Improved Roads	
Support Equipment	15K Forklift		25K Forklift	

2.4 Operational Suitability (OI-3)

2.4.1 Detailed Methodology and Approach

Four factors assessing operational suitability were analyzed including operational availability (Ao), mean time between failure (MTBF), mean time to repair (MTTR), and reliability through time curves. (b) (7)(E) , the Ao is also reported (b) (7)(E) included as downtime.

For purposes of this FDE, both the RAID and PGSS systems can each be defined as having three major subsystems: an aerostat, a tower, and GCS. These three subsystems can be further broken down into non-mission and mission critical components as described in Table 5.

Table 5: Aerostat Sub-Systems/ and Mission Critical Sensors/Equipment

PGSS	
Aerostat System	Aerostat Camera*
	Aerostat Radar*
	Aerostat
Tower System	Tower Camera*
	Tower Radar*
Ground Control Station (GCS) System	Computers*
	Communications/Data Link*
RAID	
Aerostat System	Aerostat Camera*
	Aerostat
Tower System	Tower Camera*
	Tower Radar*
Ground Control Station (GCS) System	Computers*
	Communications/Data Link*

***Mission Critical Sensors/Equipment**

Definitions for the calculation of Ao, MTBF, MTRR, and reliability used in this analysis as well as a discussion of the Ao derivation for the mission critical sensors/equipment are presented in Appendix C.

2.4.2 Limitations and Constraints

Several limitations were identified with the operational suitability data collection. First, all operations logs were not submitted into the (b) (7)(E) data collection system resulting in undocumented evaluation time. The vast majority of the evaluation time was documented, however, and the undocumented time does not significantly affect the suitability data figures. Undocumented test time was removed from the total time under test for each system.

Second, both RAID 1 and 2 experienced downtime due to lack of crew manpower to maintain 24/7 operations. For a period of time, each RAID site had less than the full complement of crew members needed to launch the aerostat, and thus had to keep the aerostat moored. Lack of manpower only affected the aerostat balloons, and did not affect the tower or GCS systems. RAID 1's Aerostat system operations time experienced the greatest impact from the lack of manpower. For reliability calculations, lost time due to lack of manpower was considered as standby time and was not counted as operational time for the purpose of collecting reliability data. Normally, some standby time is encountered and is usually counted as uptime for operational availability calculations; however, the large amount of standby time in this FDE

would skew the result if it were included as uptime, and could create an inaccurate representation of the systems under evaluation. Thus, standby time was not included in operational availability calculations.

Third, the PGSS underwent a configuration change midway through its operational period. Its radar was removed and replaced with a second camera in order to allow operators to better track multiple groups of IoIs. Therefore, while this report does provide suitability results for the PGSS, it is based on two different baseline configurations and normally would not be included. See Appendix C for supporting data on these limitations.

Finally, it should be noted that in reliability testing it is standard practice to conduct the entire test with the same components from start to finish. If a repairable component fails, the time to repair it is logged, then, after repairs are completed, the repaired component continues to be tested in order to determine how long it operates until another failure. In other words, the baseline configuration of the system under test is not usually changed during reliability testing. This evaluation was conducted as an FDE, not as a pure reliability test. Thus, during the FDE time period, if an infrared camera failed, it was either repaired quickly or replaced with a new camera. Reliability data for the original camera is lost when the baseline changes, but overall system availability is accurately represented.

2.4.3 **Environmental Considerations**

(b) (7)(E)

(b) (7)(E)

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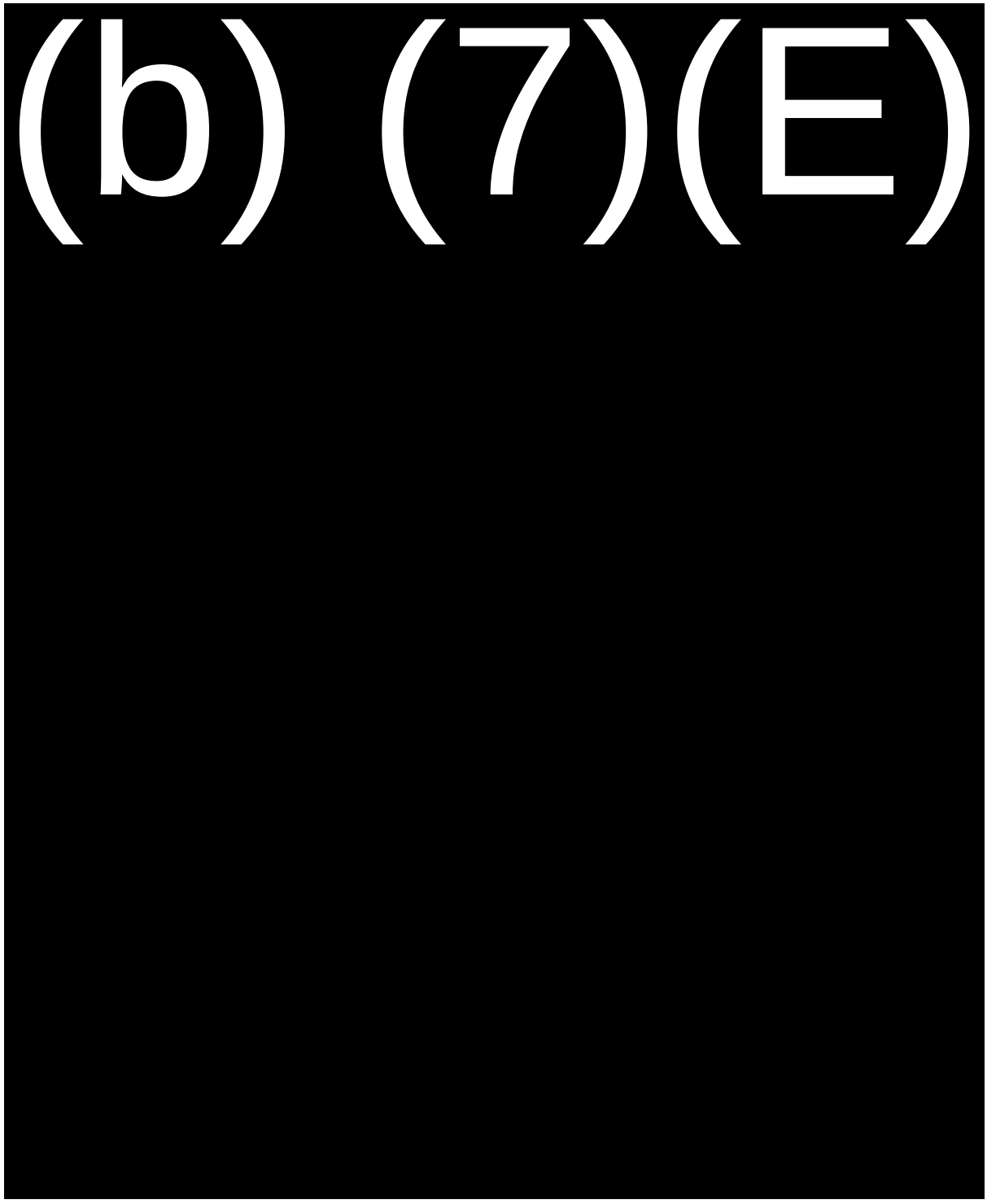
2.4.4 **Safety Considerations**

Based on CBP Officer observations, (b) (7)(E) USBP TTPs should be developed to preclude additional unforeseen issues such as this from happening.



2.4.5 **OS Findings and Analysis**

Availability

Availability (b) (7)(E) is provided in Table 6 and supporting data are provided in Appendix C.

Table 6: RAID/PGSS Availability (b) (7)(E)

Measure	RAID 1 System	RAID 1 Tower	RAID 1 Aerostat	RAID 1 GCS
Availability (b) (7)(E)	(b) (7)(E)			
Operational Availability (b) (7)(E)				
Measure	**RAID 2 System**	**RAID 2 Tower**	**RAID 2 Aerostat**	**RAID 2 GCS**
Availability (b) (7)(E)	(b) (7)(E)			
Operational Availability (b) (7)(E)				
Measure	**PGSS System**	**PGSS Tower**	**PGSS Aerostat**	**PGSS GCS**
Availability (b) (7)(E)	(b) (7)(E)			
Operational Availability (b) (7)(E)				

Maintainability and Reliability

Calculated maintainability factors (MTTR and MTBF) are provided in Table 7. Note, MTTR and MTBF were not calculated for the PGSS due to the mid-FDE operations configuration change.

Table 7: RAID/PGSS MTTR and MTBF

	RAID 1 System	RAID 1 Tower	RAID 1 Aerostat	RAID 1 GCS
MTTR	(b) (7)(E)			
MTBF				
	RAID 2 System	**RAID 2 Tower**	**RAID 2 Aerostat**	**RAID 2 GCS**
MTTR	(b) (7)(E)			
MTBF				
	PGSS System	**PGSS Tower**	**PGSS Aerostat**	**PGSS GCS**
MTTR	(b) (7)(E)			

MTBF	(b) (7)(E)

(b) (7)(E)

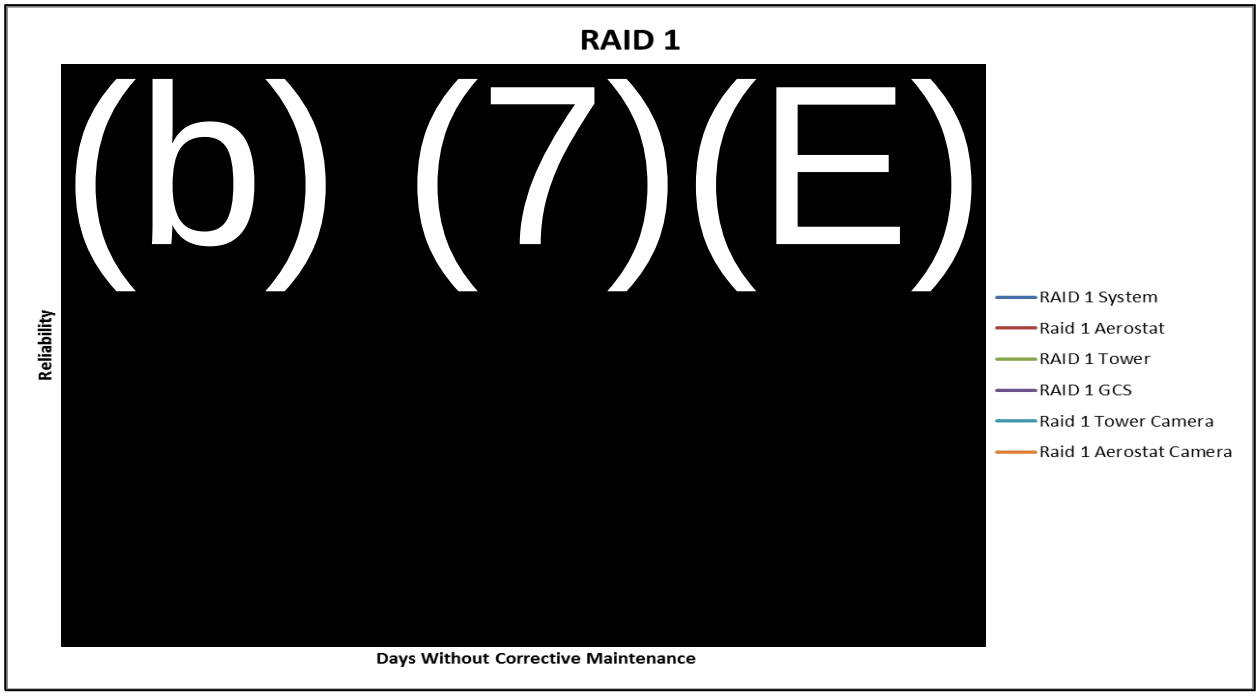


Figure 18: RAID 1 Reliability Curve

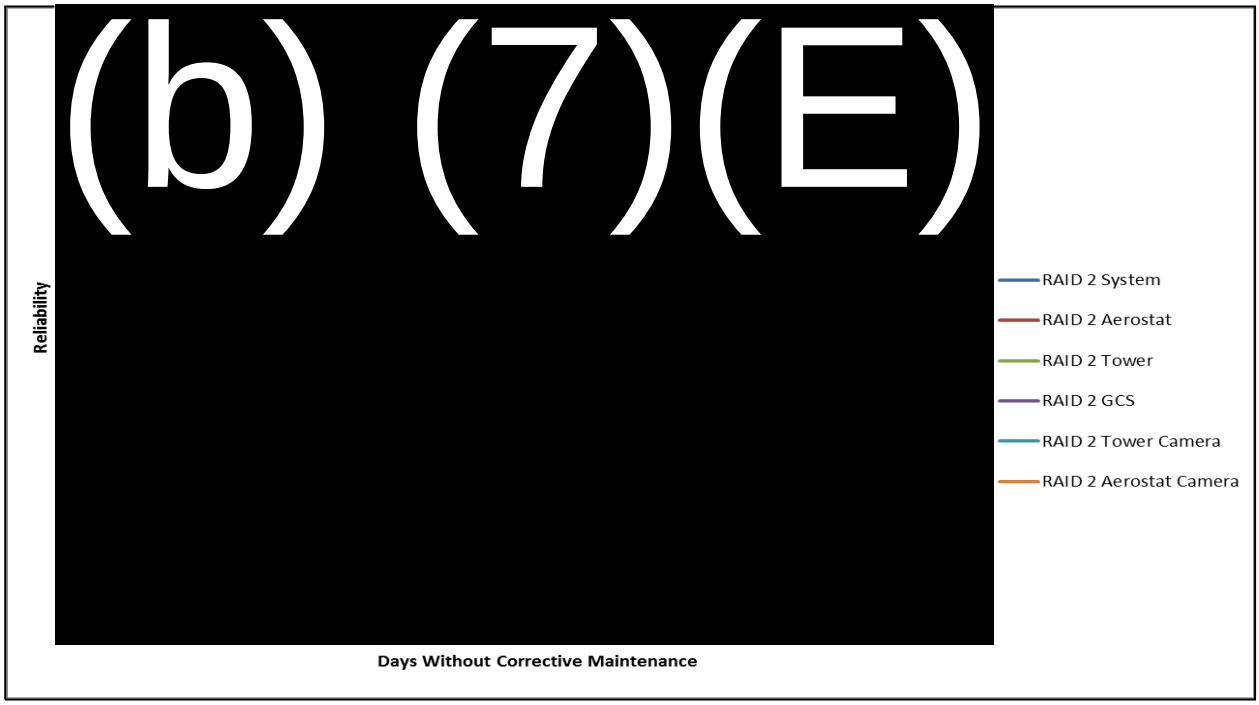


Figure 19: RAID 2 Reliability Curve

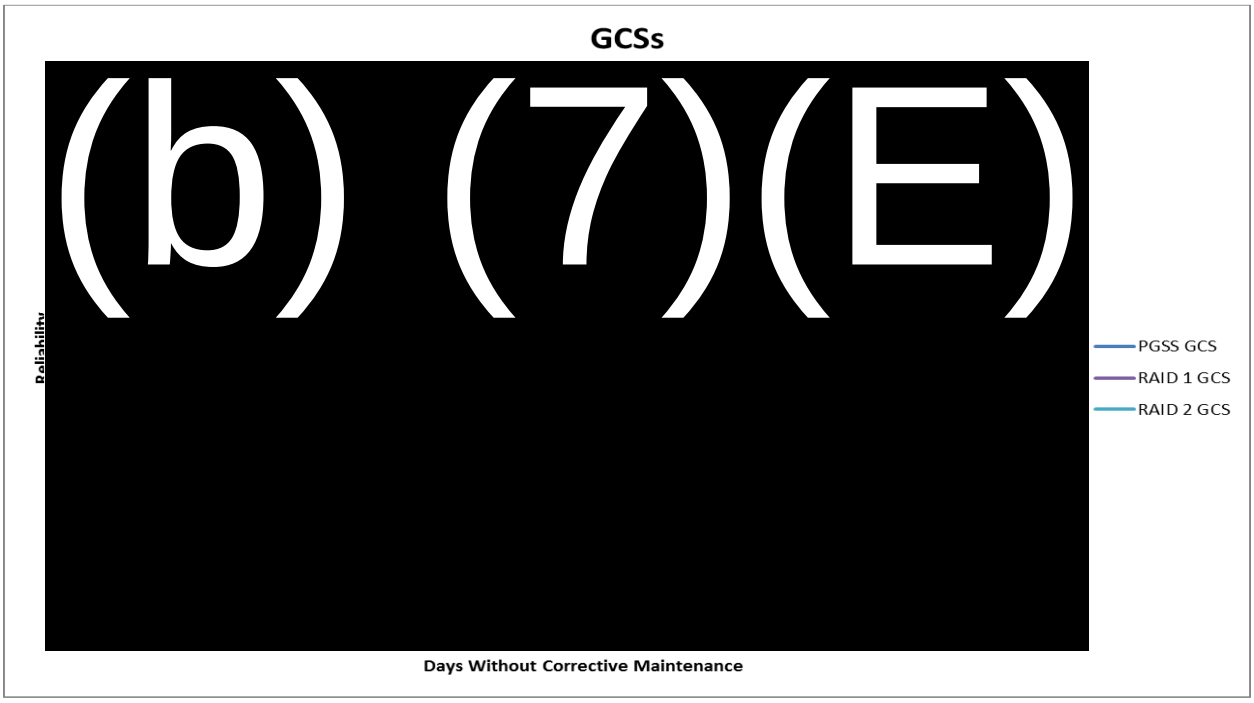


Figure 20: RAID/PGSS Reliability Curve – GCS

Failures

(b) (7)(E)

. See Appendix C for detailed description of the failures. (b) (7)(E)

(b) (7)(E)

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3 TECHNOLOGY INSERTION – (b) (7)(E)

3.1 Scope & Purpose

This section provides a summary of the results from the Operational Utility Evaluation (OUE) conducted in the Rio Grande Valley (RGV) Area of Responsibility (AoR) during two different time periods; (b) (7)(E)

. For a full report on this OUE please refer to Appendix A, Reference 6.

3.2 Findings and Analysis

3.2.1 Quantitative Findings

During the (b) (7)(E) evaluation, n(b) (7)(E) operators detected (b) (7)(E) items of interest (IoIs) during (b) (7)(E) test scenarios while the (b) (7)(E) operator during the same time detected (b) (7)(E) more detections, an increase (b) (7)(E) as shown in Table 8 below. Outside of runs-for-record testing during 15 hours of (b) (7)(E) free-play time", (b) (7)(E) operators detected (b) (7)(E) groups that were not included in the scoring.

Table 8: (b) (7)(E) OUE Quantitative Results

(b) (7)(E) Detections Made on the PGSS Aerostat						NET	Total Detects	Ratio of (b) (7)(E) Detections
Scenario Dates		4/9/14	4/11/14	4/15/14	4/16/14			
Number of Scenarios*		(b) (7)(E)						
(b) (7)(E) Operators	Human						(b) (7)(E)	(b) (7)(E)
	Vehicle							
(b) (7)(E) Operator	Human							
	Vehicle							

* Test scenarios used targets of opportunity as well as a Border Patrol vehicle and one/two agents.

3.2.2 Qualitative Findings

(b) (7)(E)

Table 9: (b) (7)(E) OUE Qualitative Results

Key Survey Questions	Strongly Agreed or Agreed	Strongly Disagreed or Disagreed	Neutral
(b) (7)(E)			

3.3 Conclusions and Recommendations

The sensor operator with (b) (7)(E) technology had a (b) (7)(E) increase in detections compared to the operator without the technology. (b) (7)(E) .

From this limited evaluation, (b) (7)(E) technology looks promising (b) (7)(E)

4 AEROSTAT/LEGACY COST ANALYSIS

4.1 Detailed Methodology and Approach

An Independent Government Cost Estimate (IGCE) was directed by the OTIA Business Operations Division (BOD) and conducted by Tecolote Research Inc. to determine the annual budgeted funding required for operating and maintaining the Aerostat (RAID/PGSS) systems. This effort started with the IGCE developed for the Aerostat OUE effort in 2012 (Appendix A, Reference 7) and revised it based on modified assumptions, different alternatives, and revised cost data. In addition, point estimates were also developed for OBP identified legacy systems (see Table 10) to be used in the ROI analysis. ROI Cost Summary and revised Aerostat IGCE Final Reports (Appendix A, References 8 and 9) provided the source for the cost data presented. Detailed ground rules and assumptions are provided in those references.

Table 10: ROI Legacy Systems

USBP Legacy Systems
SBInet Block 1

Remote Video Surveillance System (RVSS)
Mobile Surveillance System (MSS)
Mobile Video Surveillance System (MVSS)
Agent Portable Surveillance System (APSS)
Skybox with APSS Sensors
Unattended Ground Sensors (Cost Only)

For comparison purposes the estimates was made for one single system (RAID, PGSS, or legacy system) at one deployment site. For the Aerostat, the total system was defined as one aerostat (including sensors), one tower (including sensors), ground command shelter, and ancillary equipment. Since the aerostat and tower can be operated independently, estimates are provided for aerostat only, tower only, as well as total system. Legacy systems were assumed to be the configurations currently deployed with the following exceptions.

4.2 Limitations and Constraints

Estimated costs only include program management and operations & maintenance (O&M); system acquisition costs are not included in either the Aerostat or legacy cost estimates.

4.3 Aerostat Annual Budgeted Cost

The FDE was conducted with an all contractor O&M crew with the exception of the sensor operators who were BPAs so this was assumed to be the baseline cost estimate case. The annual budged cost estimates for FY15-19 are provided in Table 11.

Table 11: Annual Budgeted Cost for FY15-19 (Then Year $K) with Contractor Labor

Fiscal Year	RAID (per single system)			PGSS (per single system)		
	Aerostat Only	Tower Only	Total System	Aerostat Only	Tower Only	Total System
FY15	$5,378	$1,950	$5,629	$4,451	$1,950	$4,701
FY16	$5,323	$1,830	$5,578	$4,378	$1,830	$4,633
FY17	$5,424	$1,864	$5,684	$4,461	$1,864	$4,721
FY18	$5,599	$1,972	$5,864	$4,618	$1,972	$4,883
FY19	$6,547	$2,849	$7,731	$5,546	$2,849	$6,731
TOTAL	$28,271	$10,465	$30,485	$23,453	$10,465	$25,668

Note: Point Estimate (Non-Risk Adjusted)

This equates to an average total system operating cost per hour of $586 (RAID) and $493 (PGSS), assuming 99% availability (8,672 hours per year). The RAID system is more costly to operate due primarily to the larger crew size (b) (7)(E) for the PGSS). The smaller crew size for the PGSS is attributed to a better mooring system design.

Manpower is the primary cost driver as illustrated for the RAID baseline case in Figure 21.

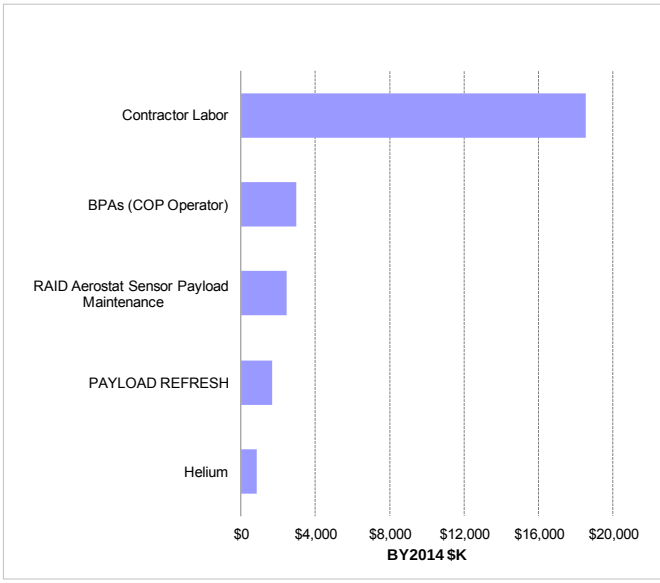

Figure 21: Figure 21: RAID Total System Base Year FY14 Estimate Cost Drivers

Manpower, both contractor labor and BPA operators, followed by payload maintenance and a technical refresh (sensors) that was assumed in year five of the analysis. Manpower is also the primary cost drivers for both the RAID and PGSS aerostat only and tower only cases. See Appendix D for the cost driver illustration for these additional cases.

4.4 Aerostat Operations & Maintenance Crew Configuration

Three O&M crew options were evaluated as provided in Table 12 for the RAID and Table 13 for PGSS. U.S. Army provided job categories and responsibilities for RAID crew positions. Based on this information, OBP Mission Support Division determined the potential grade/step of crew members as follows:

1. Flight Director = Flight Engineer, GS-2185-09
2. Winch Operator = Aircraft Attending WG-8862-06
3. Nose Line Handler = Aircraft Attending WG-8862-06
4. Payload Handler =Aircraft Loadmaster, GS-2185-07
5. Port Line Handler = Aircraft Attending WG-8862-06
6. Starboard Line Handler = Aircraft Attending WG-8862-06

For PGSS this information was not available so a crew of GS9-Step 1 was assumed. National Guard crew grade was assumed to be E-7. All BPA operators were assumed to be GS12-Step 1. See Appendix D for a complete list of ground rules and assumptions.

Table 12: RAID Annual Budgeted Cost by O&M Crew Labor Category (Then Year $K)

RAID Total System			
Fiscal Year	**Contractor Labor**	**USBP**	**National Guard**
FY15	$5,629	$3,452	$3,955

FY16	$5,578	$3,361	$3,873
FY17	$5,684	$3,424	$3,946
FY18	$5,864	$3,562	$4,094
FY19	$7,731	$5,383	$5,925
TOTAL	$30,485	$19,182	$21,793

Note: Point Estimate (Non-Risk Adjusted)

The use of USBP or National Guard O&M crews instead of contractor labor provides an average annual cost avoidance of 37 and 28 percent for the RAID and PGSS, respectively.

Table 13: PGSS Annual Budgeted Cost by O&M Crew Labor Category (Then Year $K)

PGSS Total System			
Fiscal Year	**Contractor Labor**	**USBP**	**National Guard**
FY15	$4,701	$3,413	$3,179
FY16	$4,633	$3,322	$3,083
FY17	$4,721	$3,384	$3,141
FY18	$4,883	$3,521	$3,273
FY19	$6,731	$5,342	$5,090
TOTAL	$25,668	$18,981	$17,767

Note: Point Estimate (Non-Risk Adjusted)

4.5 Aerostat Multiple Tower Configurations

Multiple tower configurations of one, three, and six towers daisy-chained to a single aerostat and GCS were also estimated. This data is presented in Tables 14 and 15 for the RAID/PGSS respectively.

Table 14: RAID Annual Budgeted Cost for Multiple Tower Configurations (Then Year $K)

RAID			
Fiscal Year	**One Tower**	**Three Towers**	**Six Towers**
FY15	$5,629	$7,227	$9,277
FY16	$5,578	$7,015	$8,789
FY17	$5,684	$7,148	$8,956
FY18	$5,864	$7,429	$9,345
FY19	$7,731	$11,081	$15,703
TOTAL	$30,485	$39,901	$52,069

Note: Point Estimate (Non-Risk Adjusted)

Table 15: PGSS Annual Budgeted Cost for Multiple Tower Configurations (Then Year $K)

Fiscal Year	PGSS		
	One Tower	**Three Towers**	**Six Towers**
FY15	$4,701	$5,559	$8,349
FY16	$4,633	$5,316	$7,844
FY17	$4,721	$5,417	$7,993

FY18	$4,883	$5,665	$8,364
FY19	$6,731	$9,283	$14,702
TOTAL	$25,668	$31,238	$47,252

Note: Point Estimate (Non-Risk Adjusted)

4.6 Legacy Systems

The legacy systems identified by OBP to be used in the ROI analysis are provided in Table 11. A complete discussion of the ROI analysis and findings is presented in the next section (5. ROI Analysis). (b) (7)(E) .

A summary comparison of the O&M cost of a single system (with the exception of UGS where (b) (7)(E) ensors were assumed) by FY for five year period of performance is provided in Table 16. This is the source of the costs used in the ROI analysis.

Table 16: Aerostat/Legacy Annual Budget Cost Estimate (Base Year FY14 $K)

System	Total	FY15	FY16	FY17	FY18	FY19
RAID	$29,036	$5,579	$5,427	$5,427	$5,496	$7,107
PGSS	$24,451	$4,662	$4,510	$4,510	$4,579	$6,190
Block 1	$13,131	$6,634	$923	$923	$923	$3,728
NB RVSS	$7,224	$3,263	$627	$628	$628	$2,078
MSS	$8,745	$2,419	$1,389	$1,389	$1,389	$2,159
MVSS	$4,194	$1,125	$680	$680	$680	$1,029
APSS	$4,656	$1,248	$738	$738	$738	$1,194
Skybox/APSS	$4,810	$1,371	$746	$746	$746	$1,201
UGS	$1,965	$449	$379	$379	$379	$379

Note: Point Estimate (Non-Risk Adjusted)

5 RETURN ON INVESTMENT ANALYSIS

5.1 Detailed Methodology and Approach

Aerostat system return on investment (ROI) was determined and compared with OBP identified CBP legacy systems to determine mission outcome benefit (Objective 3). The systems/variations (test cases) included in this analysis are identified in Table 16.

Mission outcome benefit (ROI) was defined as a function of three categories including: (1) system performance, (2) suitability, and (3) manpower/cost. The benefit of each test case was determined by a weighted analysis based on the factors identified in Table 17. Data was obtained from multiple sources including the OBP, OTIA Program Management Office and other sources. OBP was asked to prioritize metrics and rank the factors in order to complete the ROI analysis.

Table 17: ROI Categories/Factors

Category	Factor
System Performance	Area of Coverage
	Maximum Line of Sight
Suitability	Operational Availability
Manpower/Cost	Operations & Maintenance

The final outputs from this ROI analysis compared: (1) total operational cost per square area of coverage and (2) cost per square area of coverage as a function of operational availability. For this ROI analysis, effectiveness is defined as a weighted combination of the factors identified in Table 17.

Static modeling/analysis was conducted to gain insight into the relative persistent surveillance provided by an Aerostat-enabled surveillance deployment as a Return on Investment (ROI) as compared to surveillance deployment with legacy surveillance systems. System performance is affected by selection of operating location therefore, Site 1 (b) (7)(E) and Site 2 (b) (7)(E) were

selected. For purposes of this report, Site 1 data will be presented as the baseline case. The results for both sites are similar. Results for (b) (7)(E) can be found in Appendix D.

5.2 ROI Findings and Analysis

5.2.1 Coverage Comparison

Figure 22 provides a comparison of individual system's area of coverage (in square kilometers) as a function of the number systems needed to provide that coverage. Note in the case of the aerostats and towers only one system was assumed. Also, the Block 1 and NB RVSS are virtually identical in terms of coverage, thus the lines representing their coverage comparison appear as a single curve in the figure. Viewsheds and supporting data are provided in Appendix D and References 10-12 (Appendix A).

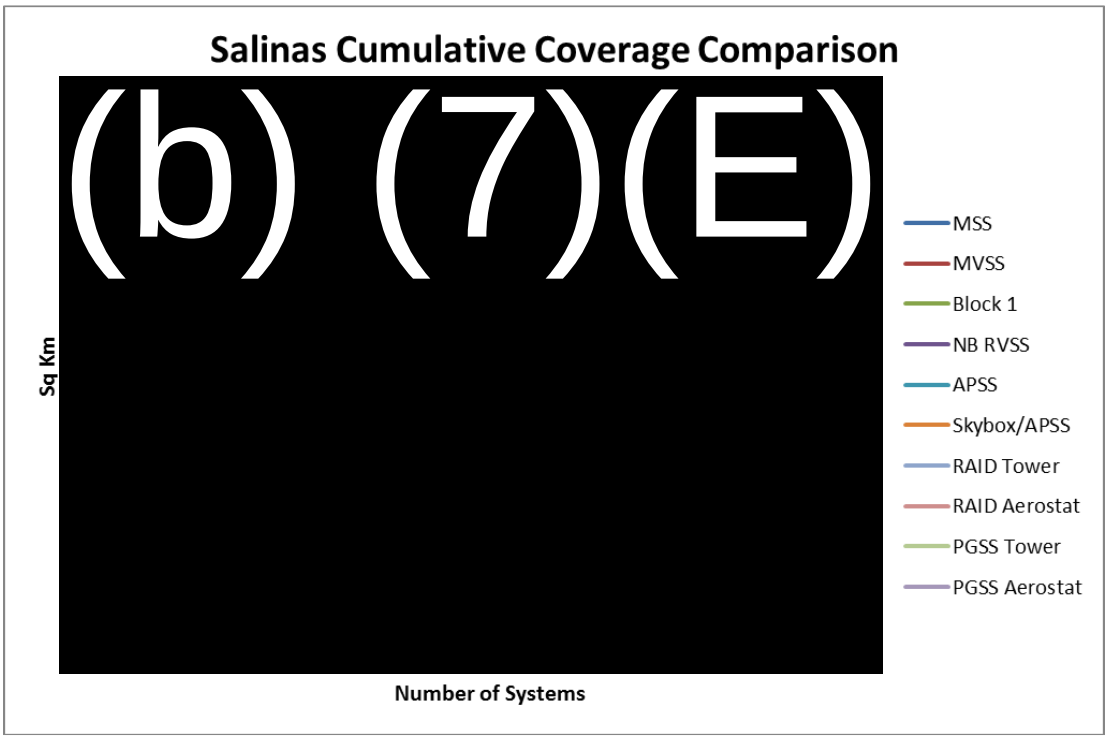

Figure 22: Area of Coverage as a function of number of systems

Tables 18 provide system performance, cost, cost per square kilometer, and operational availability for the Aerostat and Legacy systems at (b) (7)(E) The system performance of each system provides an estimated area of coverage for the system's EO/IR sensors within the specific operating area, and was based on the following assumptions. For the Aerostat Systems (RAID, RAID Tower, PGSS and PGSS tower), area of coverage estimates were based on the actual operating locations where the RAID systems were placed during the FDE. For the legacy systems (Block 1, NB RVSS, MSS, MVSS, APSS and Skybox), area of coverage is based on placing the system in an operating location that would be operationally relevant to the capability of the system. Therefore, area of coverage for the legacy systems will generally be greater than the area of coverage had they been placed in the exact location as the Aerostat systems. In all

cases, the area of coverage for each system is based on modeling outputs for a single system, as was shown in Figure 22 above.

Table 18: ROI Factor Comparison (Salinas Site)

System	System Performance (actual EO/IR coverage of (b) (7)(E) EB in sq km)	Manpower/Cost Base Year 14 (FY15-19)	Cost per Sq Km of coverage (actual EO/IR coverage of (b) (7)(E) EB)	Ao (b) (7)(E)
RAID 1 Aerostat	(b) (7)(E)	$27,062,000	(b) (7)(E)	
RAID 1 Tower		$10,017,000		
PGSS Aerostat		$22,341,000		
PGSS Tower		$9,969,000		
Block 1		$13,131,010		
NB RVSS		$7,223,230		
MSS		$8,746,141		
MVSS		$4,193,140		
APSS		$4,656,994		
Skybox/APSS		$4,808,119		

*Note: Only Inherent Availability data available

Next, an analysis was done to estimate the overall value for each system, for the purpose of comparison. The value of each system was based on the factors shown in Table 18 above for Area of coverage, Manpower/Cost, and Operational Availability. Rather than treating all factors as being equal, a sampling of users from various southwest border USBP Sectors provided weights for each of these factors in terms of how essential they should be to making decisions that impact mission accomplishment. Survey results were then analyzed and used along with the values in Table 18 to estimate the overall value of each system. Because survey results of the weighing of each factor had large variability, the value function was computed three times for each system, using a lower end, middle, and higher end weighting for each of the three factors. In each case however, the factors were ranked in the following order of importance by the users:

1. System Performance (average (b) (7)(E)
2. Operational Availability average (b) (7)(E)
3. Manpower/Cost. (average 24%)

These factor weights were then applied to the data to estimate the overall value of each system. This was done in three cases (see Table 19), where the same Operational Availability and Manpower/Cost data, was used for each case, but varied the system performance as follows:

- Case 1 used the system performance for the Aerostats as modeled at the (b) (7)(E) site, while system performance for legacy systems was based on the placement of the system in a location that would be operationally relevant to the capability of the system.

- Case 2 used system performance for all systems as modeled when placement of all systems was at the (b) (7)(E) site.

- Case 3 used system performance in a pristine environment, clear of clutter and obstructions.

Table 19: Area of Coverage for Three Value Analysis Cases

System	Case 1: Optimized Legacy Placement w/in (b) (7)(E) Enforcement Band Area of Coverage squared km	Case 2: All Systems Placed at Site 1 w/in (b) (7)(E) Enforcement Band Area of Coverage squared km	Case 3: Pristine Area of Coverage squared km
RAID	(b) (7)(E)		
RAID Tower			
PGSS			
PGSS Tower			
Block 1			
NB RVSS			
MSS			
MVSS			
APSS			
Skybox/APSS			

Figures 23, 24, and 25 shows the results of the value analysis using the different values for system performance as described above. In general, this analysis shows that the PGSS provides the greatest value when compared to legacy systems for both (b) (7)(E). The Block 1 and NB RVSS were the higher rated of the legacy systems.

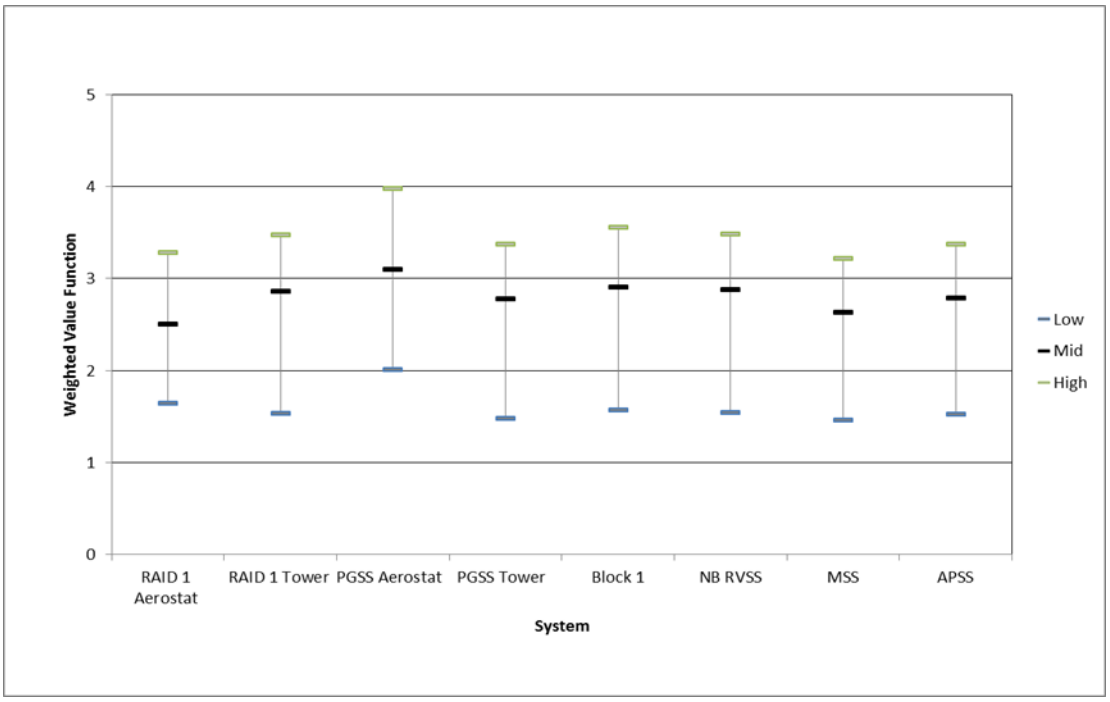

Figure 23: Value Function Outputs – Case 1

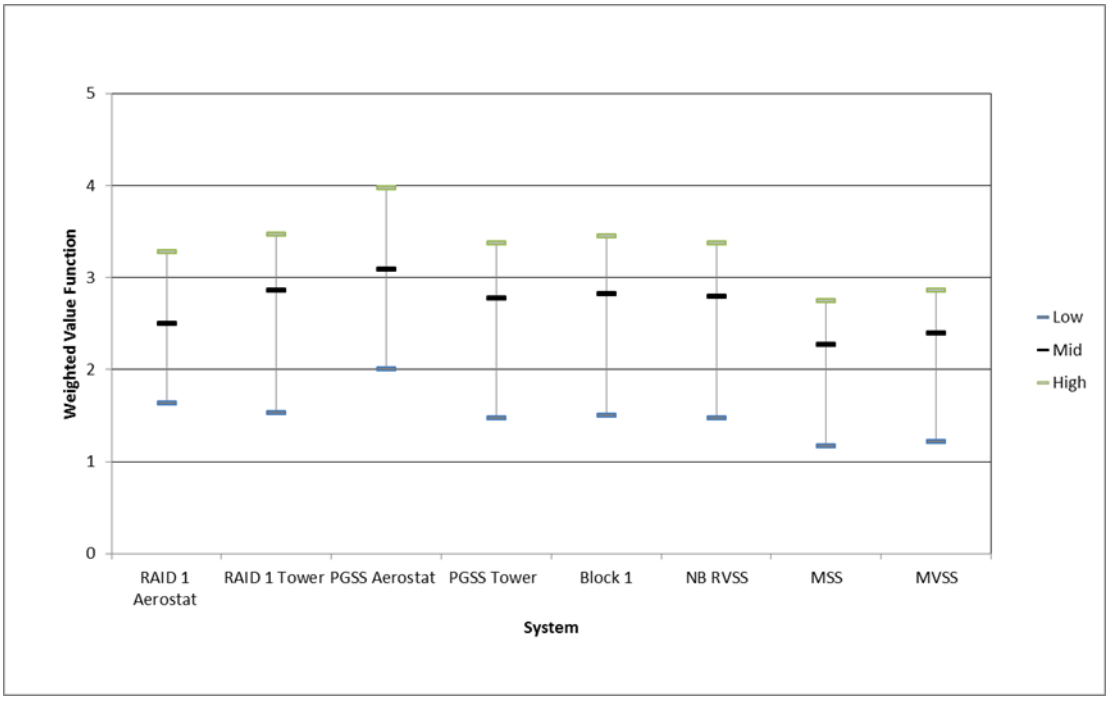

Figure 24: Value Function Outputs – Case 2

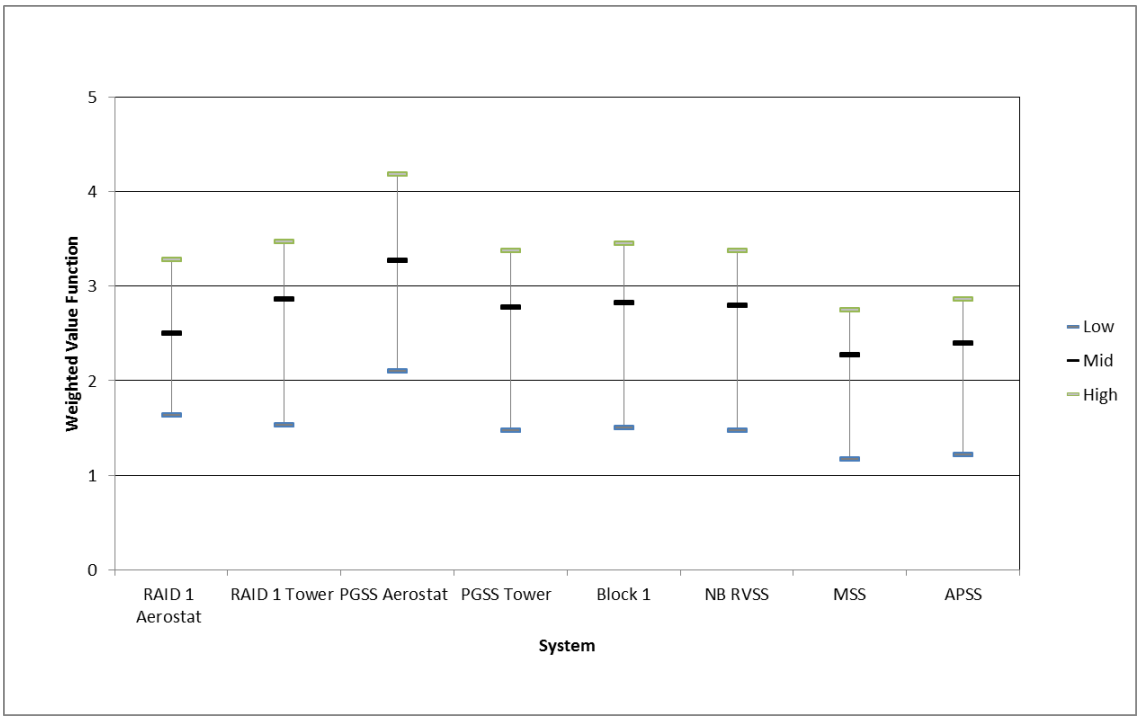

Figure 25: Value Function Outputs – Case 3

Figures 26 and 27 provide plots of Cost per Squared Kilometer of Coverage versus Operational Availability for Cases 1 and 2, respectively. This data treats all three factors as equally weighted. It should be noted that the most favorable conditions for any system would be a low Cost per Squared Kilometer of Coverage and a high Ao. Thus, a system that is plotted to the lower right would be most favorable. For both Cases, the MVSS and Skybox Ao were not captured due to insufficient data, thus these systems do not appear in either figure. In addition, for Case 2, the lower area of coverage for the APSS and MSS (0.03 km^2 and 1.5 km^2, respectively) drive their Cost per Squared Kilometer of Coverage so high that they are not plotted in this figure. While the aerostat balloons provide relatively lower cost per area of coverage, the availability ([redacted]) reduces their favorability for the RGV locations selected. Block 1 and NB RVSS provide the most favorable legacy systems for these locations.

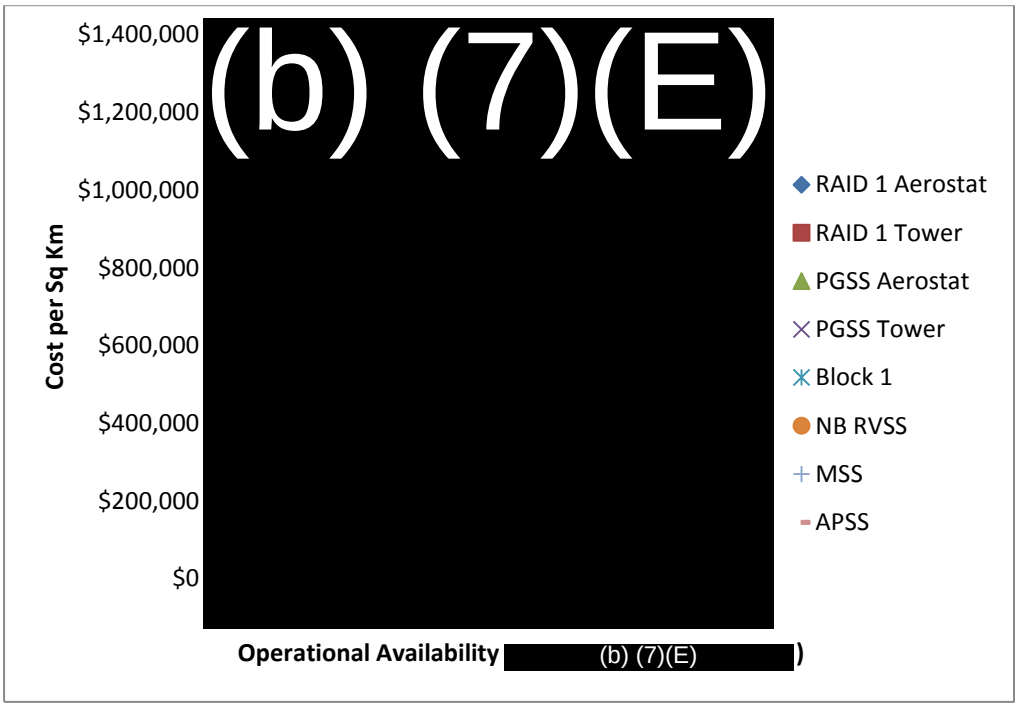

Figure 26: Cost/Sq Km vs. Ao ((b) (7)(E) Case 1)

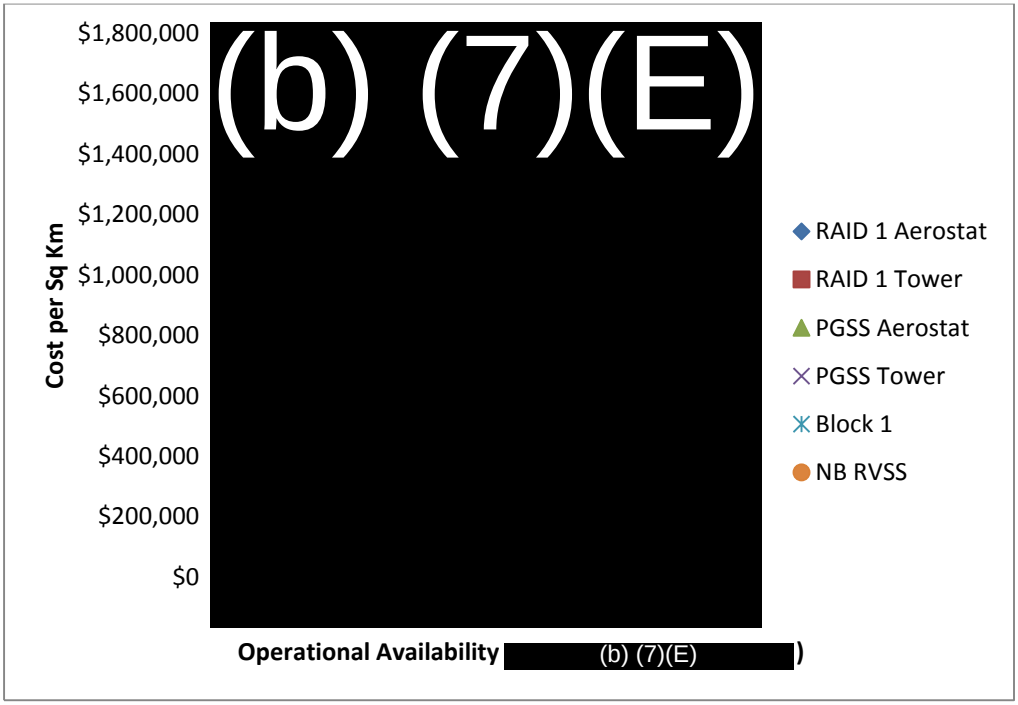

Figure 27: Cost/Sq Km vs Ao ((b) (7)(E) Case 2)

6 Conclusions and Recommendations

6.1 Onsite Evaluation

While no definitive inference can be made that Aerostat alone is responsible for the increase in apprehensions when comparing the two years side by side, it is noteworthy that substantial increases occurred in every month and that aerostat assisted apprehensions make up, in most cases, a sizable portion of the total apprehensions. The potential value of Aerostat systems as a force multiplier should be further examined and the tactics, techniques and procedures (TTPs) for Aerostat operations should be further developed to maximize the utility of Aerostat systems.

Further studies that capture the operational impact of Aerostat systems to the entire persistent surveillance mission should be examined. Carefully planned, scripted test scenarios and analysis of test data would be required to make a full assessment.

(b) (7)(E) The erect crew size/time required might not be representative therefore it is recommended that USBP develop TTPs for system transportation and system erect and stow.

The operational availability values (b) (7)(E) for all of the subsystems and components (b) (7)(E). Part of this is attributed to the fact that (b) (7)(E) (b) (7)(E) The reliability values were (b) (7)(E) (b) (7)(E), (b) (5). Also, based on BPA observations, (b) (7)(E), (b) (5). As demonstrated during this evaluation, if repair personnel and parts are available (b) (7)(E) (b) (7)(E), then the systems and components, (b) (7)(E), can be maintained to produce high operational availability.

(b) (7)(E)

6.2 Cost/ROI Analysis

The use of either USBP or National Guard crews for O&M provides significant cost avoidance over contractor labor operations.

For the Aerostat systems, airborne components provide greater cumulative coverage than towers or other ground-based systems. The RAID and PGSS towers provide coverage that is similar to the coverage that is provided by legacy systems. Using the cost analysis provided in section (Section 4.) along with the cumulative cost comparison, the computed measure of Cost per

Squared Kilometer of Coverage shows that the Aerostat systems' cost for the amount of Area of Coverage is lower than the towers or legacy systems.

(b) (7)(E)

Considerations of the trade space between cost per area of coverage versus operational availability should be taken into account when making future deployment decisions. Fixed and ground based systems will still be limited in the amount of coverage they can provide, regardless of the number of systems deployed.

APPENDIX A – References

This Appendix includes all reference documents used in the development of this document.

1. U.S. CBP Operational Interest Statement for Aerostat Systems, July 16, 2013.

2. (b) (7)(E) Aerostat Operational Utility Evaluation Final Report, November 16, 2012.

3. U.S. DHS CBP Operations Order Report Aerostat Force Development Event, No. (b) (7)(E) (b) (7)(E), July 23, 2014.

4. OBP Operations Division Decision Paper "Aerostat Effectiveness Scenarios-Proposal", undated.

5. FAA Advisory Circular AC70/7460-1K, Obstruction Marking and Lighting, February 1, 2007.

6. Operational Utility Evaluation of (b) (7)(E) Technology on Aerostats Test Report, Document Number: OTIA05-NET-77-140003, June 10, 2014

7. PGSS/RAID Independent Government Cost Estimate, September 20, 2012.

8. RAID Aerostat and Tower Independent Government Cost Estimate (IGCE), June 23, 2014.

9. Aerostat ROI Cost Results, June 23, 2014.

10. OTIA/SE/SpE/Design Branch M&S Increment 1 Report (b) (7)(E) Sensors Coverage Performance for ROI, May 29, 2014.

11. OTIA/SE/SpE/Design Branch M&S Increment 1+2 Report (b) (7)(E) Sensors Coverage Performance for ROI, June 19, 2014.

12. OTIA/SE/SpE/Design Branch M&S Increment 1+2 Backup Report (b) (7)(E) Sensors Coverage Performance for ROI, June 20, 2014.

APPENDIX B – Acronyms and Abbreviations

Ao	Operational Availability
AGL	Above Ground Level
AOR	Area of Responsibility
BPA	Border Patrol Agent
BPETS	Border Patrol Enforcement Tracking System
CBP	Customs and Border Protection
DC	Data Collector
DHS	Department of Homeland Security
DnT	Down Time
DoD	Department of Defense
EO/IR	Electro Optical/Infrared
FAA	Federal Aviation Administration
FDE	Force Development Event
(b) (7)(E)	
FY	Fiscal Year
GCS	Ground Control Station
GPS	Global Positioning System
HD	High Definition
HQ	Headquarters
ID	Identification
INS	Inertial Navigation System
IoI	Item of Interest
IP	Internet Protocol
LOS	Line of Sight
M&S	Modeling and Simulation
(b) (7)(E)	
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
N/A	Not Available
O&M	Operations and Maintenance
OBP	Office of Border Patrol

OE	Operational Effectiveness
OEB	Operational Evaluation Branch
OI	Operational Issue
OIAD	Office of Integration and Analysis Directorate
OJT	On-the-Job Training
OTD	Operational Test Director
OTL	Operational Test Lead
OS	Operational Suitability
OTIA	Office of Technology Innovation and Acquisition
OUE	Operational Utility Evaluation
PGST	Persistent Ground Surveillance Tower
PGSS	Persistent Ground Surveillance System
RAID	Rapid AEROSTAT Initial Deployment
RAM	Reliability, Availability, and Maintainability
RF	Radio Frequency
(b) (7)(E)	
ROI	Return on Investment
SA	Surveillance Area
SME	Subject Matter Expert
TOR	Test Observation Report
TTP	Tactics, Techniques, and Procedures
UpT	Up Time
USBP	United States Border Patrol

APPENDIX C – Onsite Evaluation Supporting Information

Suitability Definitions and Descriptions

Operational Availability

Operational Availability (A_o) was defined as:

$$A_O = \frac{Uptime}{Uptime + Downtime}$$

Uptime refers to the system's capability to perform the mission and downtime is the system's inability to perform a critical mission task. Uptime includes operating time, partially operational times, and non-available times. Partial operations means the system is partially mission capable, (b) (7)(E). Non-availability is defined as the system being operational but currently not deployed to perform the mission, i.e., the system is on standby. Downtime includes times when the system is non-operational because (b) (7)(E) the system requires maintenance, along with any administrative or logistics lead time. Maintenance includes preventative and corrective maintenance.

$$Uptime = Operational\ Time + Partially\ Operational\ Time + Not\ Available\ Time$$
$$Downtime = Corrective\ Maintenance + Preventative\ Maintenance + Not\ Operational\ Time$$

(b) (7)(E)

(b) (7)(E)

(b) (7)(E)

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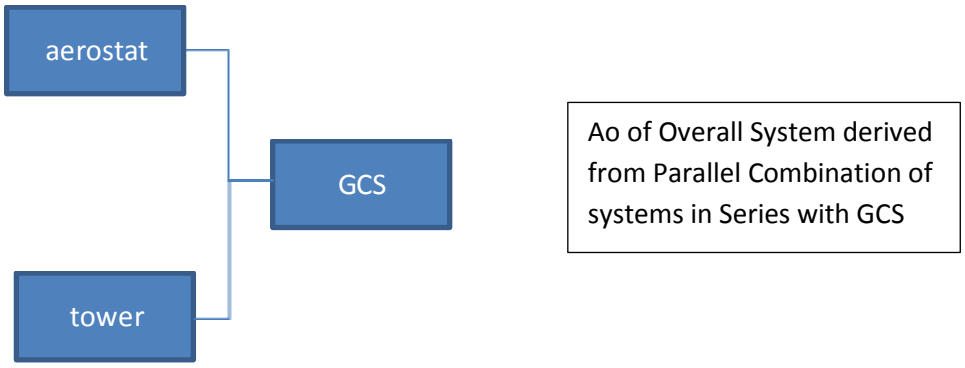
The formula for Operational Availability using this model of the system is:

(b) (7)(E)

The Overall RAID 1, RAID 2, or PGSS System is modeled with the Aerostat and the Tower in parallel (if one is up, then the system is up) and the GCS in series (b) (7)(E)



The formula for Overall RAID 1, RAID 2, or PGSS System operational availability is:

(b) (7)(E)

Example: (b) (7)(E)

Mean Time between Failure

MTBF is measure of the time between system failures and for this FDE was determined by:

$$MTBF = \frac{Total\ Operating\ Time}{Total\ Number\ of\ Failures}$$

The total number of failures only considers those failures associated with corrective maintenance and total operating time is the time the system is being operated for its intended mission.

Reliability

Reliability is a function of Mean Time between Failure:

$$R(t) = \exp(-\frac{t}{MTBF})$$

Mean Time to Repair

In this FDE, Mean Time To Repair (MTTR) was used to capture suitability data pertaining to Maintainability. MTTR is an arithmetic average of how fast the system is repaired, measuring the ease with which a system can be restored to a functioning state, and will be defined as follows:

$$MTTR = \frac{Total\ Corrective\ Maintenance\ Time}{Total\ Number\ of\ Failures}$$

where the total number of failures only corresponds to those issues that were associated with corrective maintenance actions.

Supporting Ao data

Supporting data used to calculate availability is as follows.

Measure	RAID 1 System	RAID 1 Tower	RAID 1 Aerostat	RAID 1 GCS
Up time (fully or partially mission capable)	(b) (7)(E)			
Non-mission capable Down time ((b) (7)(E))				
Down time due to corrective or preventative maintenance				
Availability (b) (7)(E)				
Operational Availability (b) (7)(E))				

Measure	RAID 2 System	RAID 2 Tower	RAID 2 Aerostat	RAID 2 GCS
Up time (fully or partially mission capable)	(b) (7)(E)			
Non-mission capable Down time ((b) (7)(E)				
Down time due to corrective or preventative maintenance				
Availability (b) (7)(E)				
Operational Availability (b) (7)(E)				

Measure	PGSS System	PGSS Tower	PGSS Aerostat	PGSS GCS
Up time (fully or partially mission capable)	(b) (7)(E)			
Non-mission capable Down time (b) (7)(E)				

Measure	PGSS System	PGSS Tower	PGSS Aerostat	PGSS GCS
Down time due to corrective or preventative maintenance	(b) (7)(E)			
Availability (b) (7)(E)				
Operational Availability (b) (7)(E))				

Total Countable time used for Ao calculations are as follows:

Measure	RAID 1 Aerostat	RAID 2 Aerostat	PGSS Aerostat
Total time under test	(b) (7)(E)		
Undocumented time/%			
Lack of manpower time/%			
Total countable time/%			

Measure	PGSS (b) (7)(E)	PGSS
Total time under test	(b) (7)(E)	
Undocumented time/%		
Lack of manpower time		
Total countable time/%		

Measure	RAID 1 GCS	RAID 1 Aerostat	RAID 1 Tower	RAID 1 System
Total time under test (Nov 2-Apr 30)	(b) (7)(E)			
Undocumented time/%				
Total countable time/%				

Measure	RAID 2 GCS	RAID 2 Aerostat	RAID 2 Tower	RAID 2 System
Total time under test (Nov 29-Apr 30)	(b) (7)(E)			
Undocumented time/%				
Total countable time/%				

Measure	PGSS GCS	PGSS Aerostat	PGSS Tower	PGSS System
Total time under test (Jan 14-Apr 30)	(b) (7)(E)			
Undocumented time/%				
Total countable time/%				

Failures

Failures resulting in a down system for the RAID are as follows:

Date	Component	Malfunction	Total System Down Time (percentage of total time)
9 Nov 2013	(b) (7)(E)		
13 Nov 2013			
8 Dec 2013			
28 Jan 2014			
14 April 2014			
15 April 2014			
13 Jan 2014			
15 Jan 2014			

Failures resulting in a down system for the PGSS are as follows:

Date	Component	Malfunction	Total System Down Time (percentage of total time)
23 Feb 2014	(b) (7)(E)		
21 Feb 2014			
10 Feb 2014			
28 Jan 2014			
28 Jan 2014			
29 Jan 2014			
29 Jan 2014			
30 Jan 2014			
30 Jan 2014			
31 Jan 2014			
31 Jan 2014			
1 Feb 2014			
1 Feb 2014			
1 Feb 2014			
2 Feb 2014			
2 Feb 2014			
9 Feb 2014			
5 Feb 2014			
6 Feb 2014			
7 Feb 2014			

Date	Component	Malfunction	Total System Down Time (percentage of total time)
18 Jan 2014	(b) (7)(E)		
19 Feb 2014			
26 Jan 2014			
26 Jan 2014			
27 Jan 2014			
31 Jan 2014			
21 Jan 2014			

APPENDIX D – ROI Supporting Data

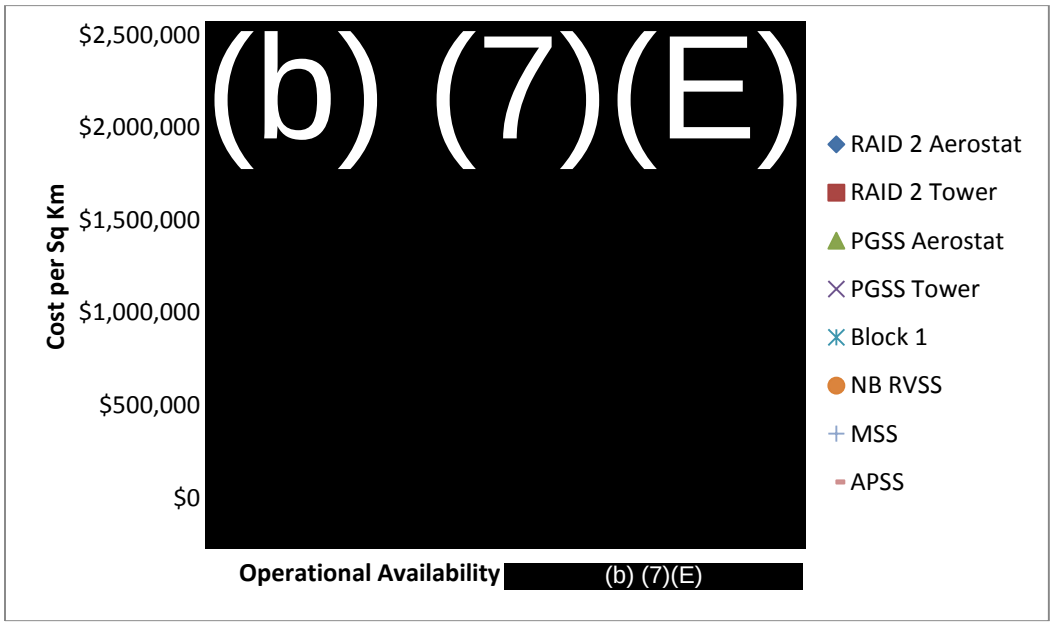
(b) (7)(E) ROI Supporting Data

ROI Factor Comparison (b) (7)(E) Site)

System	System Performance (actual EO/IR coverage of (b) (7)(E) EB in sq km)	Manpower/Cost Base Year 14 (FY15-19)	Cost per Sq Km of coverage (actual EO/IR coverage of (b) (7)(E) EB)	Ao (b) (7)(E)
RAID 2 Aerostat	(b) (7)(E)	$27,062,000	(b) (7)(E)	(b) (7)(E)
RAID 2 Tower		$10,017,000		
PGSS Aerostat		$22,341,000		
PGSS Tower		$9,969,000		
Block 1		$13,131,010		
NB RVSS		$7,223,230		
MSS		$8,746,141		
MVSS		$4,193,140		
APSS		$4,656,994		
Skybox/APSS		$4,808,119		

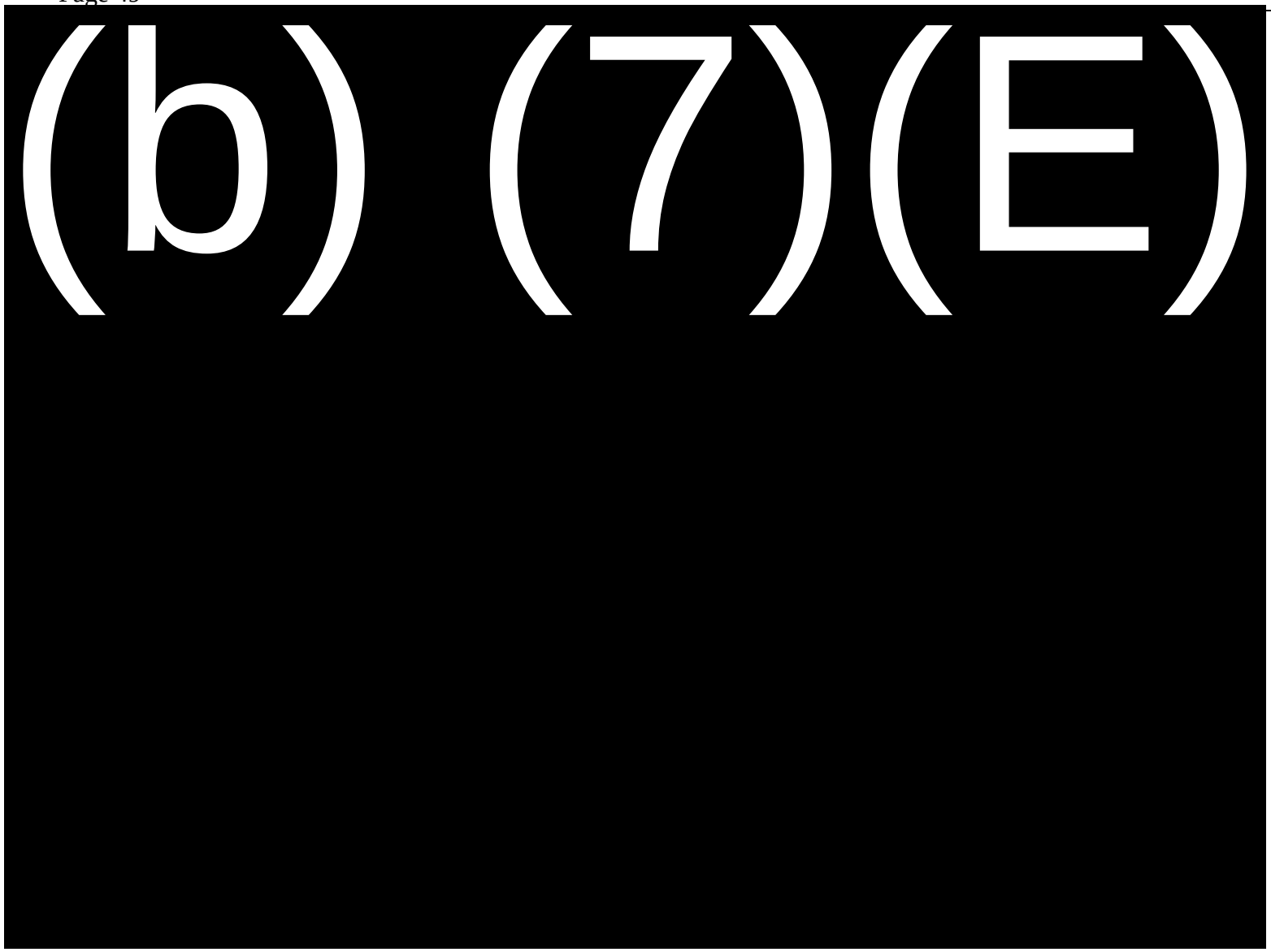
*Only Inherent Availability data available

Cost/Sq Km vs. Ao (b) (7)(E)



Viewsheds

The viewsheds provided on the following pages provide the source data for the area of coverage used in the ROI analysis.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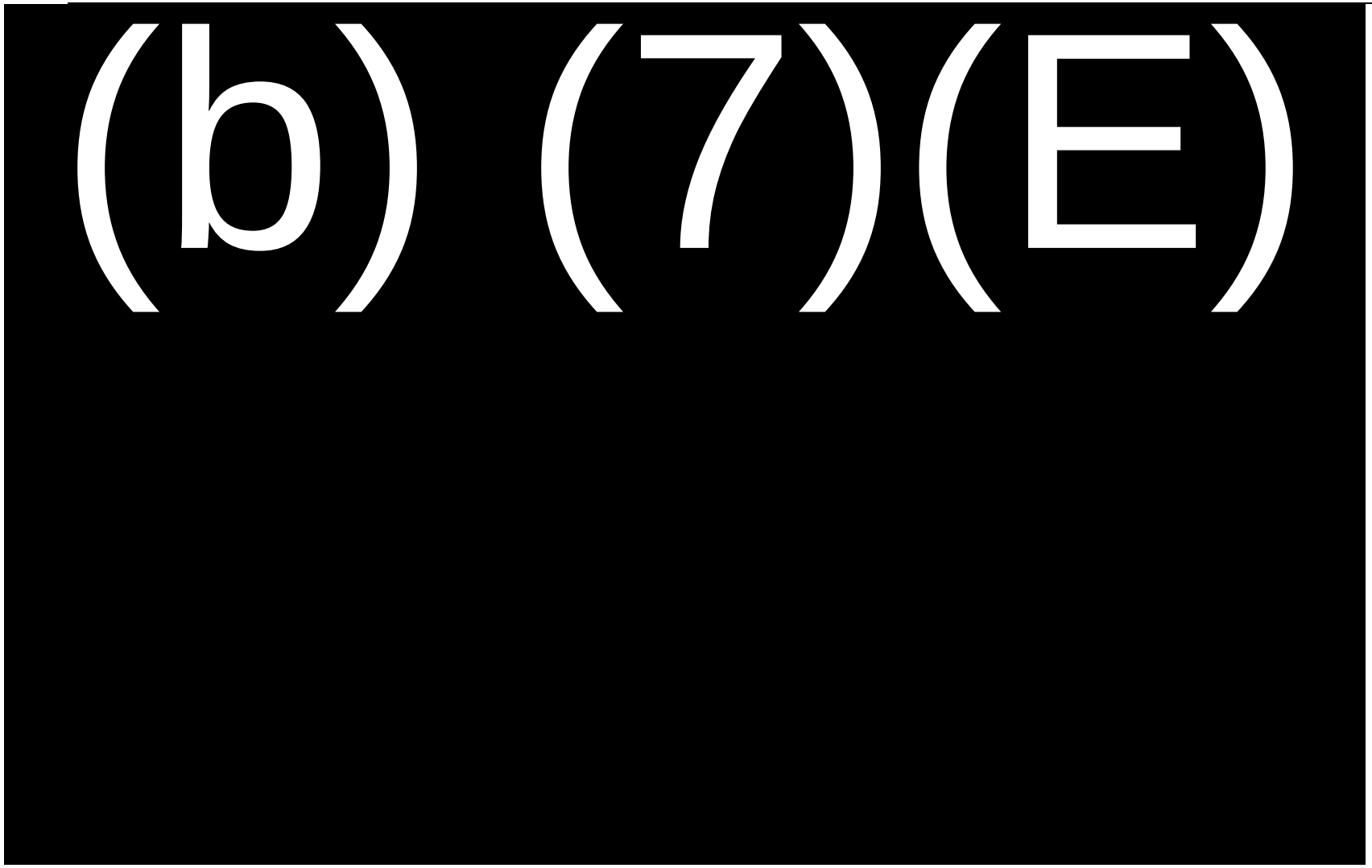
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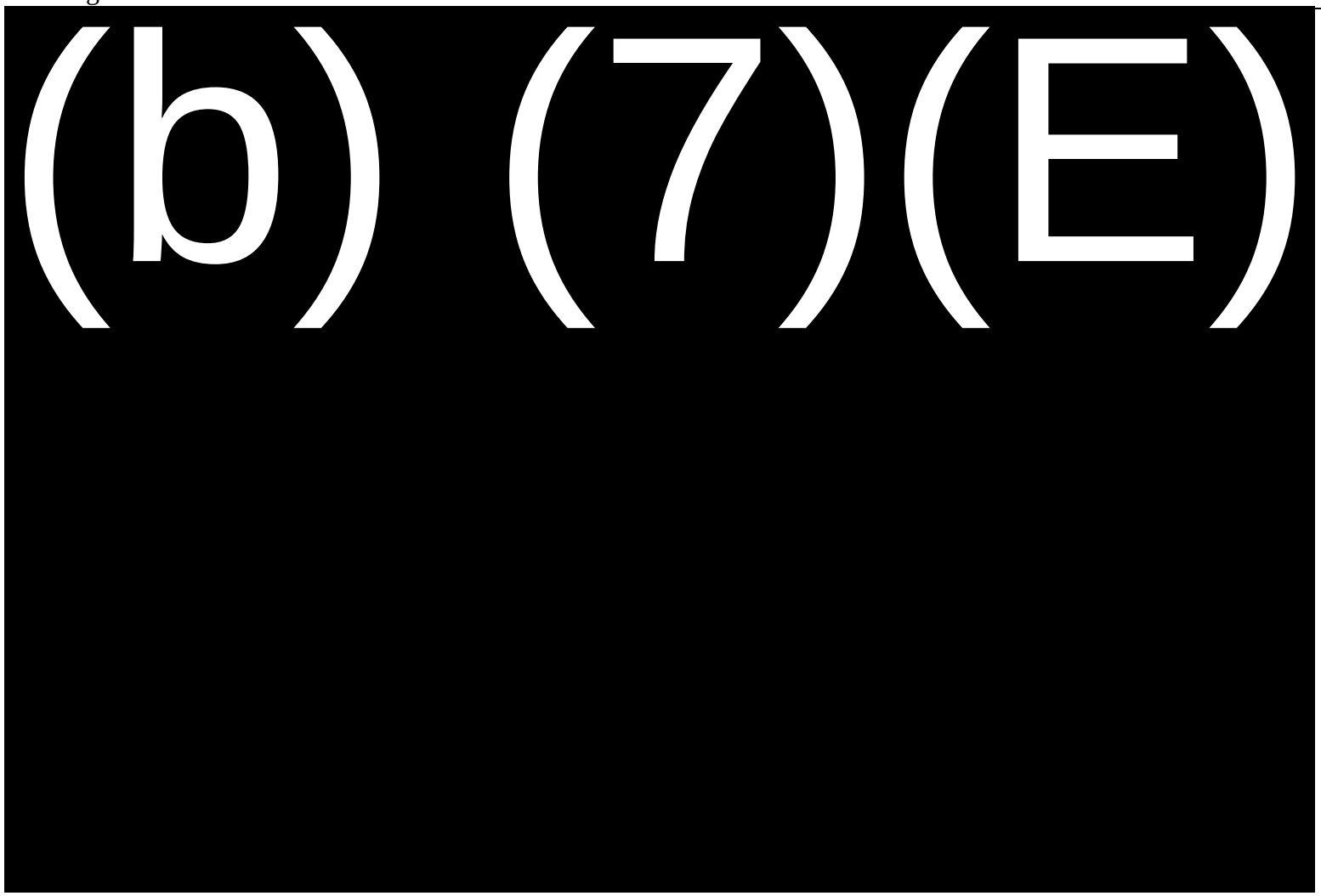
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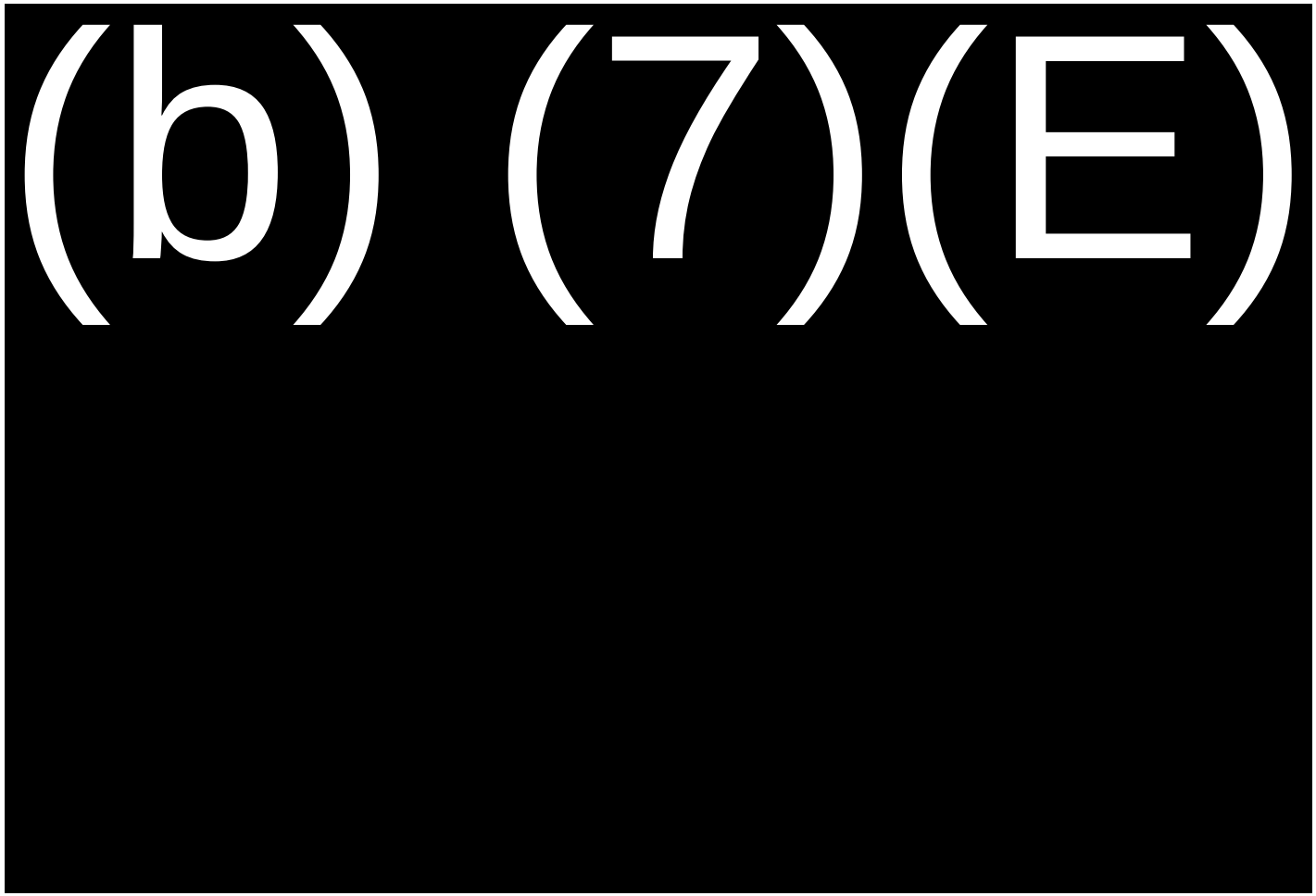
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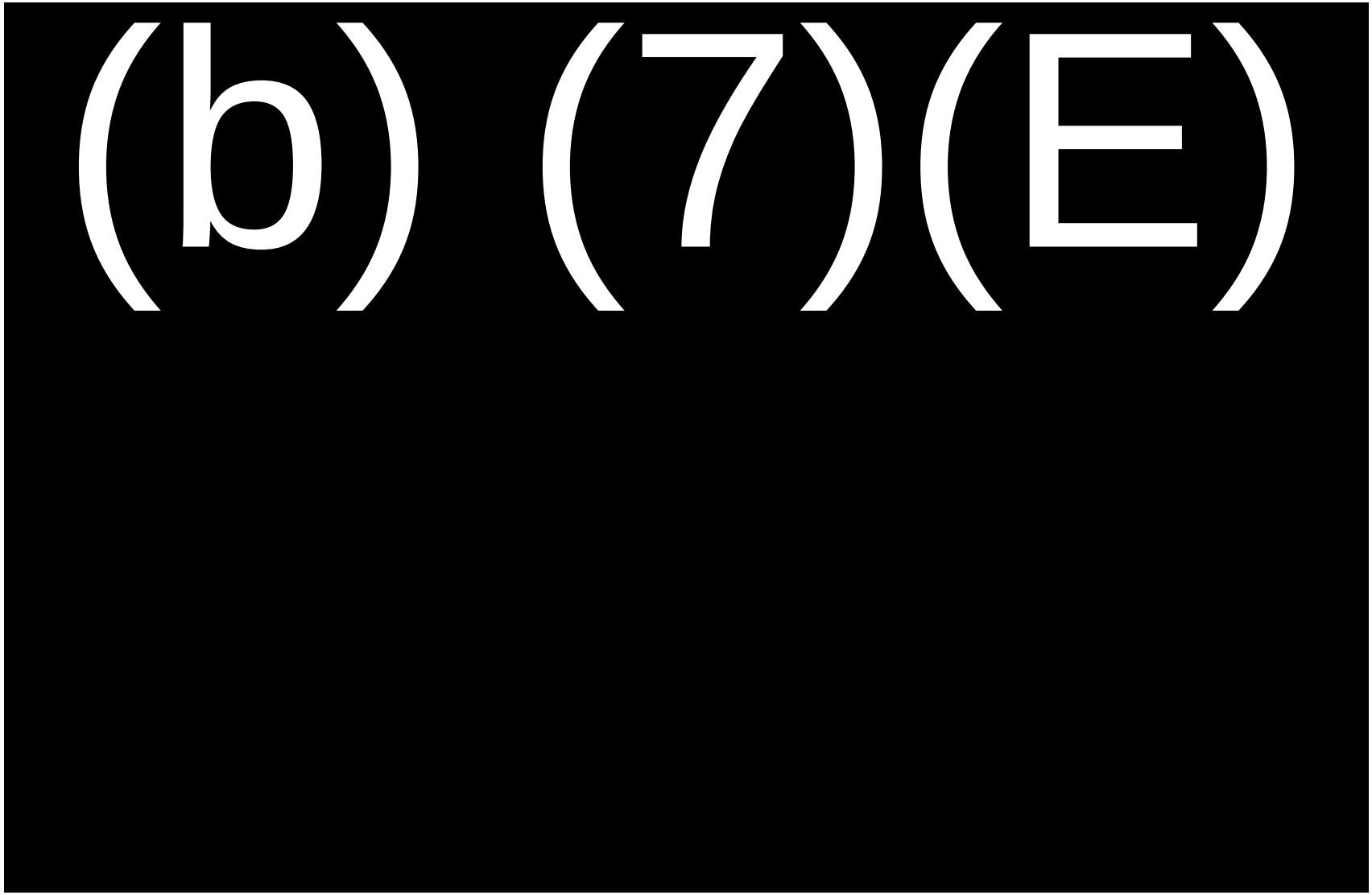
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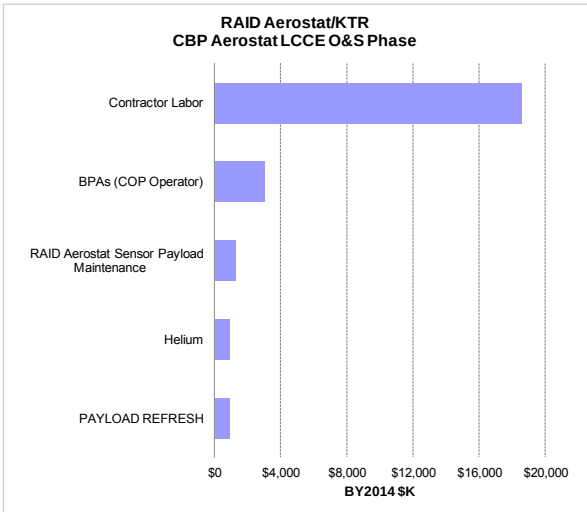
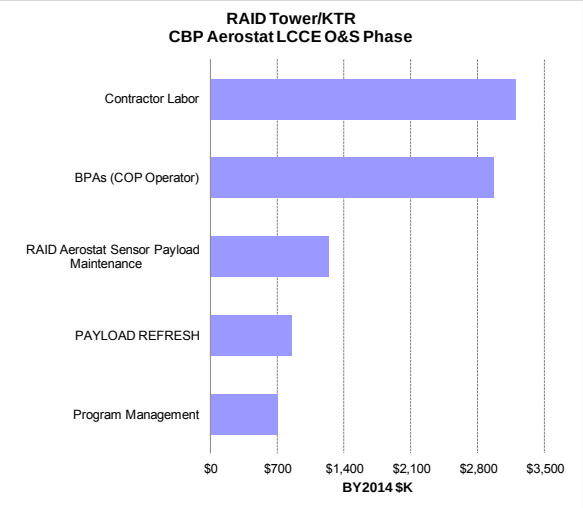
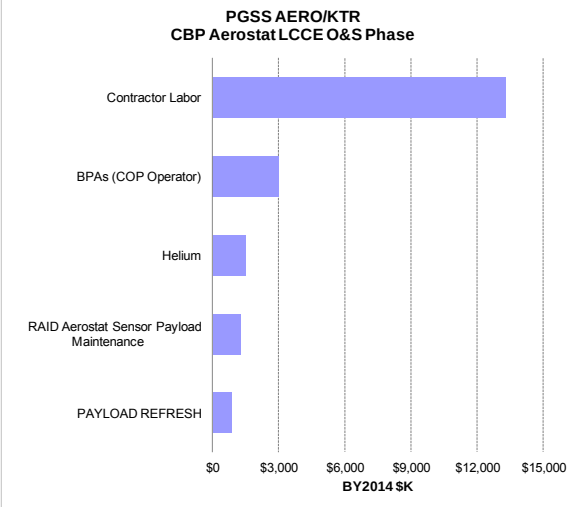
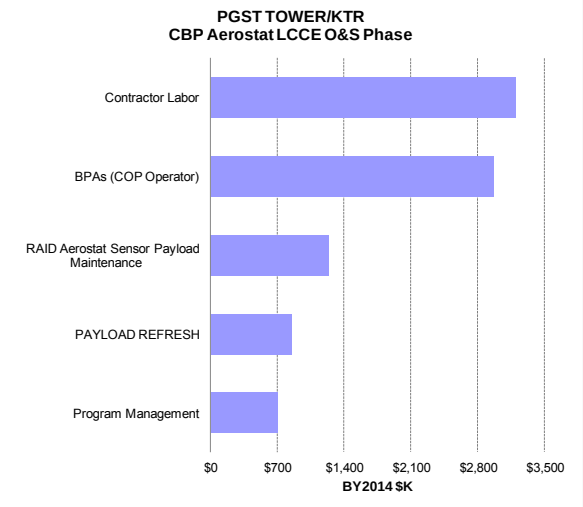
Cost Analysis Supporting Data









APPENDIX E – FDE Evaluation Report Authors/ Supporting Personnel

Team Member	Role	Organization
(b) (6), (b) (7)(C)	OEB Director/FDE Evaluation Team Leader	OIAD
	Deployment Team Lead	OIAD
	(b) (7)(E) Site Deployment Lead	OIAD
	Evaluator/(b) (7)(E) Operational Test Director	OIAD
	Lead Evaluator	MANTECH/WILLCOR
	Lead ORSA	MANTECH
	Operational Test Lead	MANTECH
	(b) (7)(E) Operational Test Lead	MANTECH
	Data Collection Manager	MANTECH
	Suitability Analyst	MANTECH
	System Performance Analyst	MANTECH
	System Performance Analyst	MANTECH